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RESEARCH ARTICLE

Financial Frictions and the Fiscal Theory of Price Level Determination

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Abstract The fiscal theory of the price level represents a significant departure from the quantity theory of money, as it implies that active (non-Ricardian) fiscal policy provides the nominal anchor and determines the price level. In this paper we take a first pass at integrating discussion of financial frictions and the fiscal theory of the price level. We first present empirical evidence in support of non-Ricardian fiscal policy, and then discuss the fiscal theory of the price level in a world with financial frictions. After illustrating how the financial friction influences the price level, we provide a theoretical explanation to our empirical findings. We also argue that the financial friction, which is related to fiscal policy, provides an additional instrument tool to the fiscal authority and an advantage over the monetary authority in choosing the equilibrium.

Keywords Collateral rates · Fiscal theory of the price level · Monetary-fiscal interactions

JEL Classification E31 · E58 · H63

1 Introduction

As Sims (2013, p. 563) put it in his Presidential Address at the 125th meeting of the American Economics Association,

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> "Drastic changes in central bank operations and monetary institutions in recent years have made previously standard approaches to explaining the determination of the price level obsolete. Recent expansions of central bank balance sheets and of the levels of rich-country sovereign debt, as well as the evolving political economy of the European Monetary Union, have made it clear that fiscal policy and monetary policy are intertwined. Our thinking and teaching about inflation, monetary policy, and fiscal policy should be based on models that recognize fiscal-monetary policy interactions."

One theory that has been developed over the last two decades to recognize the interaction between monetary and fiscal policy is the fiscal theory of the price level (FTPL). It has been developed primarily by Leeper (1991), Woodford (1994, 1995), Sims (1994), and Cochrane (2001, 2005). The theory is an extension of the Sargent and Wallace (1981) 'monetarist arithmetic,' the first attempt of studying the intertemporal relationship between policy instruments. It integrates discussion of monetary and fiscal policy suggesting that fiscal policy can be a determinant, or even the only determinant, of the price level. This is in contrast to the quantity theory approach in which fiscal policy plays little or no role in determining the price level. See Canzoneri et al. (2001) and Sims (2013) for more details regarding the basic tenets of the fiscal theory of the price level.

One problem with the fiscal theory of the price level is that it ignores financial frictions (asymmetric information problems that act as a barrier to the efficient allocation of capital), although it is now widely recognized that financial frictions can lead to financial crises and major disruptions in economic activity. For example, leverage cycles (fluctuations in collateral rates) can have important effects on the level of economic activity. In fact, as Geanakoplos (2012, p. 387) recently put it, "collateral rates or leverage can be more important to economic activity and prices than interest rates, and more important to manage." In fact, the global financial crisis and the Great recession that followed have changed our view about the importance of financial frictions in the macroeconomy. We have moved from a regime where financial frictions do not matter (prior to the crisis) to a world where financial frictions matter a lot.

In this paper we take a first pass at integrating discussion of financial frictions and fiscal and monetary policy interactions. In doing so, we examine the role of fiscal policy in guaranteeing price level determinacy in a simplified version of the Angeletos et al. (2013) model. Unlike Angeletos et al. (2013) who examine the Ramsey plan in which prices and determinacy play no role, we introduce a financial friction into an endowment economy and then assess the implications for the fiscal theory of the price level in a decentralized equilibrium. In our model, each time period is divided into a morning and an afternoon. Agents can only transfer resources between the morning and afternoon each day using private loans that are backed by government bonds as collateral. Each morning agents borrow to supplement their endowment in their morning consumption and then, in the afternoon, they pay off their loans and consume again. The interest rate on private loans reacts as an endogenous variable to clear the private loan market in the morning. The financial friction is a collateral constraint, according to which households can only borrow up to a fraction δ of their government bond holdings. It is assume that preferences are linear in afternoon consumption, so that any heterogeneity in afternoon income is absorbed by afternoon consumption and every consumer has the same choice of savings.

We start the paper by providing an empirical investigation of the relevance of the fiscal theory of the price level, updating the Canzoneri et al. (2001) analysis. They showed that certain time series properties of U.S. fiscal surpluses and liabilities have a natural interpretation in Ricardian regimes, and a rather convoluted interpretation in non-Ricardian regimes (which we identify with the fiscal theory of the price level). We reproduce the Canzoneri et al. (2001) results for the sample period from 1966Q1 to 2016Q1. Then we show how these properties change for the period from 2008Q4 to 2016Q1, when the nominal interest rate is at the zero lower bound. Although this period covers only eight years (and only eight annual budgetary processes), our empirical investigation makes the non-Ricardian explanation plausible, keeping of course in mind that, as noted by Canzoneri et al. (2001), finite periods of passive monetary policy can exist in a Ricardian regime if agents expect active policies in the future.

Motivated by our empirical evidence regarding the relevance of the fiscal theory of the price level, we then integrate discussion of financial markets, financial frictions, and fiscal and monetary policy interactions, in the context of an optimal growth model with a market for private loans backed by government bonds as collateral. The idea of a collateral constraint is consistent with short-term financing arrangements in the U.S. financial system, as they are reflected in the repurchase (or repo) market which has a daily turnover of about $4 trillion. In particular, U.S. government securities account for about 40 % of the most common collateral types, followed by agency mortgage-backed securities and collateralized mortgage obligations (which account for about 34 %). Our theoretical results suggest that the fiscal theory of the price level is more important in models with financial markets and financial frictions. We show that collateral rates affect the aggregate price level as well as the size of the monetary and fiscal policy effects on the price level. We also show that coordination of monetary and fiscal policy is required to achieve price stability. Finally, in the context of 'active' and 'passive' monetary and fiscal policies, as in Leeper (1991), we investigate the implications of financial frictions for actual policies and show that the fiscal authority has an advantage in choosing the equilibrium.

The paper is organized as follows. In the next section, we briefly discuss the fiscal theory of the price level and its empirical relevancy. In Sections 3 and 4, we derive the theoretical implications of the fiscal theory of the price level in the context of an optimal growth model with a borrowing constraint, and provide theoretical support and an explanation of our empirical findings. In Section 5, we investigate the effects of financial frictions in the context of 'active' and 'passive' monetary and fiscal policies, as in Leeper (1991). The last section closes with a brief summary and conclusion.

2 Is the FTPL Empirically Relevant?

Our work is motivated by Sims's (2013) appeal for research that takes seriously the interaction between monetary and fiscal policy. Although this is an important topic, many economists are skeptical about the fiscal theory of the price level and the question that arises is whether there is any evidence to suggest that economies are in this type of regime. In this section we appeal to the existing literature and make a case for why the fiscal theory of the price level is empirically relevant.

2.1 The Present Value Budget Constraint

The fiscal theory of price level determination can be illustrated in the context of the government's present value budget constraint. The government's budget constraint can be written in nominal (per household) terms as

$$-S_t = M_{t+1} - M_t + \frac{B_{t+1}}{1+i_t} - B_t \tag{1}$$

where M_t is nominal money, B_t the nominal stock of bonds at the end of period t, P_t the price level, i_t the nominal interest rate, and S_t is the government's primary surplus.

Following Canzoneri et al. (2001), let's add and subtract $q_t M_{t+1}$, where $q_t = 1/(1+i_t)$, on the left-hand side of Eq. 1, divide both sides by nominal GDP, Y_t, and rearrange to get

$$\frac{M_t + B_t}{Y_t} = \left[\frac{S_t}{Y_t} + (1-q_t)\frac{M_{t+1}}{Y_t}\right] + \left[q_t \frac{Y_{t+1}}{Y_t}\frac{M_{t+1}+B_{t+1}}{Y_{t+1}}\right].$$

This equation can be written as

$$w_t = \xi_t + \varkappa_t w_{t+1} \tag{2}$$

where w_t is the ratio of total government liabilities, $B_t + M_t$, to nominal GDP, ξ_t is the primary surplus (including the government's revenue from money creation) to GDP ratio, and $\varkappa_t = q_t Y_{t+1}/Y_t$ is the discount factor. By recursive substitution forwards, taking expectations, and applying the 'limiting condition'

$$\lim_{T\to\infty} E_t \left(\prod_{k=t}^{T+t-1} \varkappa_k\right) w_{t+T} = 0 \tag{3}$$

Equation 2 yields the government's present value budget constraint

$$w_t = \xi_t + E_t \sum_{j=t+1}^{\infty} \left(\prod_{k=t}^{j-1} \varkappa_k\right) \xi_j \tag{4}$$

where $E_t(\cdot)$ denotes the mathematical expectation conditioned on information available in period t. It is to be noted that the two expressions in Eqs. 3 and 4 are equivalent ways of writing the present value constraint, which says that the value of government liabilities equals the discounted value of government surpluses.

2.2 Ricardian and Non-Ricardian Fiscal Policies

In terms of the present value constraint (4), we can now distinguish between Ricardian and non-Ricardian policies, as in Woodford (1995). In particular, policy paths constrained by Eq. 4 for all price level and discount factor paths, are called *Ricardian*

(R) regimes. That is, in Ricardian regimes (4) is interpreted as a budget constraint that must be satisfied, meaning that primary surpluses respond automatically to debt to assure fiscal solvency for any path of the price level and the discount factor.[1] For example, in infinite-horizon, representative agent models, Ricardian equivalence holds and (for a given amount of current and future government consumption) a deficit-financed cut in lump-sum taxes must simultaneously be accompanied by planned future tax increases to leave the present value in Eq. 4 unchanged.

By contrast, the new fiscalist theory of price level determination imposes (3), treating it as the household's a transversality condition that must hold as a result of utility maximization, to justify characterizing (4) as an equilibrium condition that determines the price level, rather than a budget constraint — see Woodford (1995). In other words, according to the fiscal theory of the price level, Eq. 4 holds only at the equilibrium price level (and not at all price levels). This means that at price levels different than the equilibrium price level, the government could run surpluses whose present value in Eq. 4 is not equal to the government's liabilities. Similarly, it means that the government could run a deficit-financed tax cut without simultaneously planning to raise future taxes.

Hence, in Ricardian regimes primary surpluses respond automatically to debt to assure fiscal solvency and the price level is determined in conventional ways (by the interaction of money demand and money supply). In non-Ricardian regimes, however, primary surpluses follow an arbitrary process (unrelated to the level of government debt), and the equilibrium price level 'jumps' to satisfy the government's present value budget constraint — that is, there is a unique price level for which (4) holds.

Hence, the difference between R and NR regimes is that monetary policy provides the nominal anchor for the economy in the former and fiscal policy in the latter.

2.3 Empirical Evidence

Although no formal statistical test has yet been developed to discriminate between R and NR regimes, Canzoneri et al. (2001) assess the empirical plausibility of R and NR regimes, using annual data for the postwar U.S. economy (from 1951 to 1995), in the context of the following VAR in w_t (Liabilities/GDP) and ξ_t (Surplus/GDP)

$$\xi_t = \alpha_1 + \sum_{j=0}^{r} \alpha_{11}(j)\xi_{t-j} + \sum_{j=0}^{s} \alpha_{12}(j)w_{t-j} + \varepsilon_{st} \tag{5}$$

$$w_t = \alpha_2 + \sum_{j=0}^{r} \alpha_{21}(j)w_{t-j} + \sum_{j=0}^{s} \alpha_{22}(j)\xi_{t-j} + \varepsilon_{wt} \tag{6}$$

In doing so, they focus on the impulse response functions to ξ_t shocks, computed for both orderings of the variables. In the first ordering, ξ_t comes first (assumed to

[1] There is a large literature that treats (3) or (4) as a budget constraint restricting government fiscal and monetary policy, and tests (3) or (4) as a test of government solvency — see, for example, Hamilton and Flavin (1986) and Ahmed and Rogers (1995).

be exogenous), as is consistent with an NR regime (in NR regimes ξ_t is assumed to be exogenous and therefore an innovation to the ξ_t equation can be identified as an exogenous ξ_t shock). In the second ordering, w_t comes first, as is consistent with an R regime (in R regimes, ξ_t is endogenous and the ξ_t equation in the VAR can be thought of as a reaction function in which w_t influences the setting of future surpluses).

Canzoneri et al. (2001) find that the response of ξ_t to a positive ξ_t innovation is positive and significant in period 1, but insignificant beyond period 1, regardless of the ordering of the variables in the VAR. They also find that the response of w_t to a positive ξ_t innovation is negative and significant (at least up to ten years), regardless of the ordering. As they report, these VAR results are robust across different sample periods, as well as to the inclusion of a deterministic time trend, the use of different lag lengths, the estimation in first differences, and the inclusion of discount factors.

In this paper we use quarterly data for the United States, over the period from 1966Q1 to 2016Q1 to update and extend the results reported by Canzoneri et al. (2001). The data are constructed as in Canzoneri et al. (2001) and the two key series that we analyze, w_t (Liabilities/GDP) and ξ_t (Surplus/GDP), are shown in Fig. 1 with the shaded area indicating the period over which the zero lower bound constraint on the policy rate has been binding.

We begin by fitting the Canzoneri et al. (2001) VAR, Eqs. 5 and 6 and we set the lag length equal to 5, based on a pre-estimation procedure that includes a number of lag length selection criteria. Moreover, our results are robust to including linear trends as well. Black lines in Fig. 2 show the impulse response functions (over an expanse of 10 years) for both orderings of the variables; in the ordering of top panel Liabilities/GDP comes first and in the bottom panel Surplus/GDP comes first. Blue lines denote 95 % confidence interval, computed using the Monte Carlo method with 2000 draws.

In general, regardless of the ordering used, our results are consistent with those in Canzoneri et al. (2001) and support an R regime, as the negative response of w_t to a positive innovation in ξ_t has a plausible interpretation in an R regime. In particular,

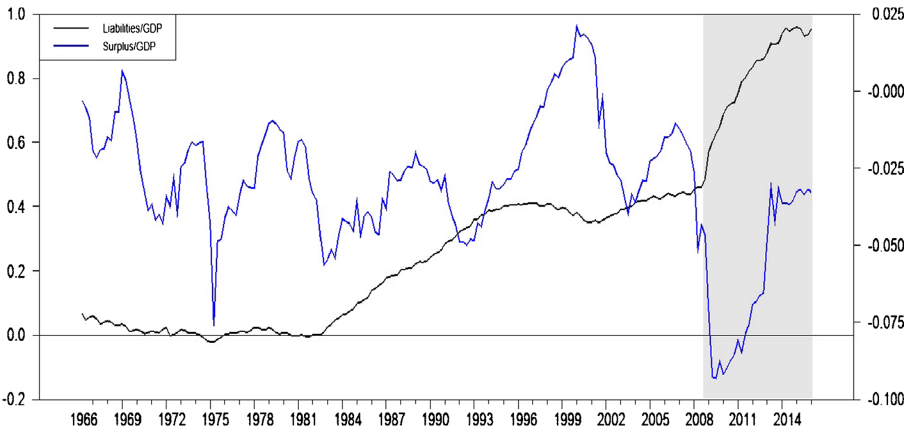

Fig. 1 United States fiscal data over the period 1966Q1-2016Q1. Liabilities/GDP (on the *left scale*) and Surplus/GDP (on the *right scale*)

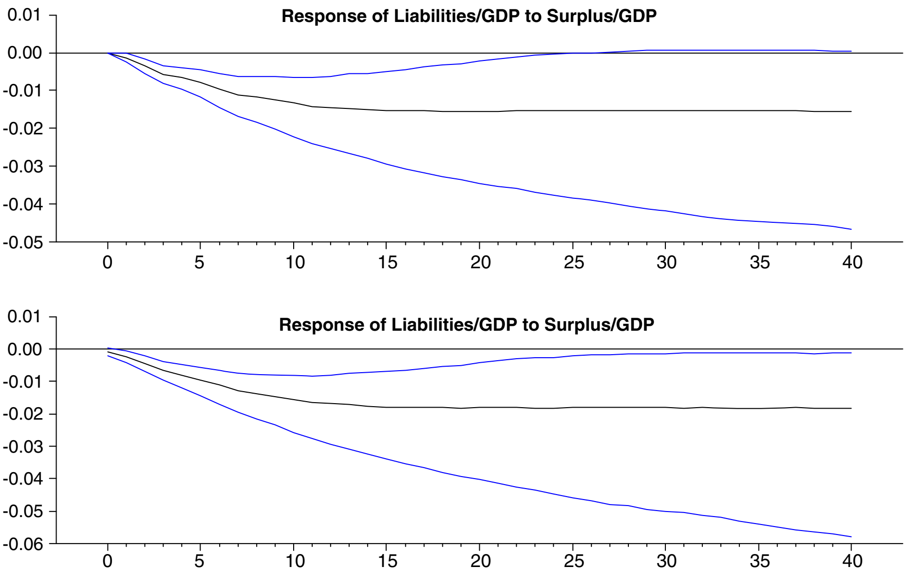

Fig. 2 VAR impulse responses over the sample 1966Q1-2016Q1. Panel (**a**) ordering: Liabilities/GDP, Surplus/GDP. Panel (**b**) ordering: Surplus/GDP, Liabilities/GDP

a positive ξ_t innovation reduces w_{t+1} by paying off some of the debt in period t. Moreover, because of election cycles and business cycles, there is significant positive correlation in the ξ_t process as can be seen in Table 1, and also in Canzoneri et al. (2001, Table 1), causing a rise in future surpluses and a fall in future liabilities (as the VAR shows). There is, however, an identification problem, in the sense that the same impulse response functions and surplus autocorrelations have a logically consistent [although somewhat 'convoluted,' in the terminology of Canzoneri et al. (2001)] interpretation in NR regimes.

Table 1 Autocorrelations of Surplus/GDP, 1966Q1-2016Q1

Lag	Autocorrelation	Q-statistic	p-value
1	0.946	181.9	0.000
2	0.892	344.1	0.000
3	0.820	481.9	0.000
4	0.747	596.8	0.000
5	0.663	688.0	0.000
6	0.577	757.3	0.000
7	0.497	809.0	0.000
8	0.417	845.7	0.000
9	0.344	870.8	0.000
10	0.279	887.2	0.000

In particular, from the logic of NR regimes, the positive correlation in the ξ_t process implies that a positive innovation in ξ_t should cause w_{t+1} to rise. However, this is inconsistent with the impulse responses from the VAR, according to which (as already noted) the response of w_t to a positive ξ_t innovation is negative (at least up to ten years). Although these VAR impulse responses can be reconciled with the theory of NR regimes if there is (strong) negative correlation in the surplus process at longer horizons [so that a positive ξ_t innovation lowers expected future surpluses sufficiently to reduce the present value in Eq. 4], the estimated surplus autocorrelations in Table 1, and in Canzoneri et al. (2001, Table 1), do not show such a negative correlation making it difficult to rationalize an NR regime interpretation of the data.

In Fig. 3 we present impulse response functions (in the same fashion as those in Fig. 2, but over an expanse of 10 quarters in this case) for both orderings of the variables over the period from 2008Q4 to 2016Q1, based on Eqs. 5–6; we set the lag length equal to 1, based on the same pre-estimation that we used for the full sample. Over this period, the federal funds rate has been at the zero lower bound and this has greatly reduced the effectiveness of conventional monetary policy and potentially increased the effectiveness of fiscal policy.

As can be seen in Fig. 3, the response of Liabilities/GDP to an innovation in Surplus/GDP is positive and significant (up to ten quarters) regardless of the ordering used, consistent with an NR regime interpretation of the data over this

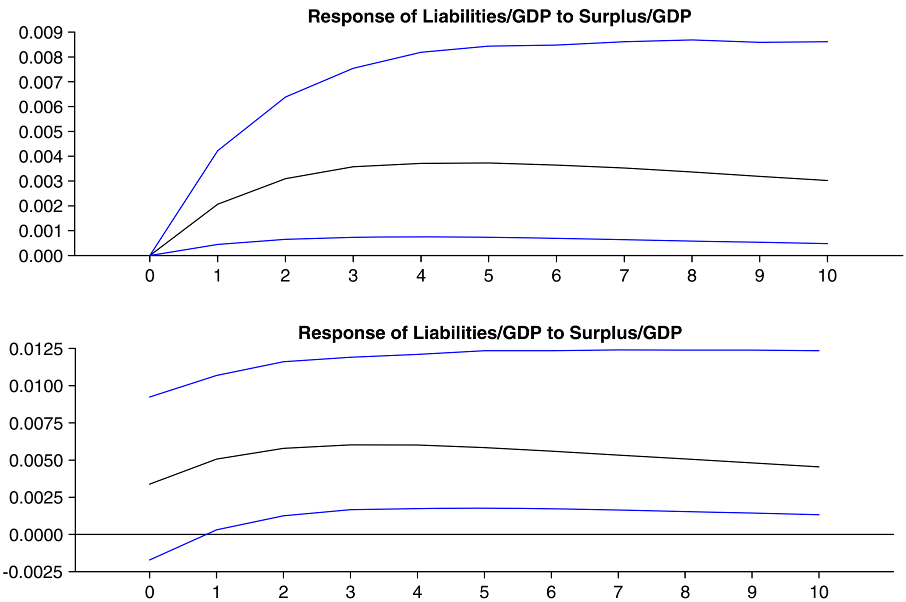

Fig. 3 VAR impulse responses over the sample 2008Q4-2016Q1. Panel (**a**) ordering: Liabilities/GDP, Surplus/GDP. Panel (**b**) ordering: Surplus/GDP, Liabilities/GDP

Table 2 Autocorrelations of Surplus/GDP, 2008Q4-2016Q1

Lag	Autocorrelation	Q-statistic	p-value
1	0.935	28.9	0.000
2	0.834	52.8	0.000
3	0.721	71.3	0.000
4	0.599	84.5	0.000
5	0.466	92.9	0.000
6	0.322	97.0	0.000
7	0.182	98.4	0.000
8	0.046	98.5	0.000
9	−0.090	98.9	0.000
10	−0.242	101.7	0.000

period of passive (conventional) monetary policy. Moreover, the estimated surplus autocorrelations in Table 2 reveal positive correlations in the surplus process as well.

We have found evidence (although limited because of the smaller sample compared with the full sample) in support of an NR regime, and consequently of the fiscal theory of price level determination, in the United States in the aftermath of the global financial crisis. Over this period, conventional monetary policy has been ineffective, because the policy rate has reached the zero lower bound and cannot be driven below zero. The Federal Reserve has resorted to unconventional monetary policy (quantitative easing, long-term bond purchases, and managing expectations) in order to lower long-term interest rates and stimulate the economy. There is also a general consensus now that unconventional monetary policy tools will likely be kept in the Federal Reserve's toolkit, because the zero lower bound constraint on the policy rate is binding more frequently than it used to (for example, in 2003-2004 and in the aftermath of the global financial crisis), and lasts longer (close to eight years now, since October 2008).

In what follows, we take a first pass at integrating discussion of the fiscal theory of the price level and financial frictions given that the global financial crisis and the Great Recession that followed have elevated financial frictions to the center stage of macroeconomic dynamics. We provide a theoretical explanation for the switch from Ricardian to non-Ricardian fiscal policy after 2008.

3 A Model with Borrowing Constraints

We set up an optimal growth model with a collateral constraint. Our model is a modified version of Angeletos et al. (2013). We study the effects of policies that tighten the collateral constraint and address current discussions regarding the need for financial stability policies to manage financial frictions.

3.1 Model Set Up

In this economy there is a continuum of infinite-lived consumers indexed by $j \in [0, 1]$. Time is discrete and there are two sub-periods in each period t, the morning (1) and the afternoon (2). The period-t utility function of consumer j is $u(c^1_{jt}, c^2_{jt}, m_{jt+1})$, where m_{jt+1} is real money balances at the end of period t and c^1_{jt} and c^2_{jt} denote real consumption in, respectively, the morning and afternoon of period t. The utility function is assumed to satisfy $u_i(c^1_{jt}, c^2_{jt}, m_{jt+1}) > 0$ and $u_{ii}(c^1_{jt}, c^2_{jt}, m_{jt+1}) < 0$ for $i = 1, 2, 3$.

Consumer j faces two budget constraints in each period t, the morning constraint and the afternoon constraint. In the morning, consumer j consumes c^1_{jt} units of consumption and makes a private loan z_{jt} at the price $\theta_t = 1/\left(1 + r^l_t\right)$, where r^l_t is the rate of return on private loans. We write the morning budget constraint as

$$c^1_{jt} + \theta_t z_{jt} = e^1_{jt}$$

where e_{jt} is the exogenous endowment in the morning. Consumer j will be a borrower (saver) if $z_{jt} < 0$ ($z_{jt} > 0$). Following Angeletos et al. (2013), we assume the following utility function

$$u(c^1_{jt}, c^2_{jt}, m_{jt+1}) = A_{jt} \log c^1_{jt} + c^2_{jt} + \log m_{jt+1} \tag{7}$$

where A_{jt} is an idiosyncratic taste shock which determines whether consumer j is a borrower or a lender. There are two types of consumers depending on A_{jt} and e^1_{jt} values. In particular, (A_{jt}, e^1_{jt}) is either $(1, 1)$ or (A, e), where $A \geq 1$, $e \leq 1$ and $A \neq e$. If $(A_{jt}, e^1_{jt}) = (1, 1)$, consumer j will have a low taste shock and/or a high endowment in the morning. Therefore, consumer j will desire to save and so she is a saver. On the other hand, consumer j will be a borrower if she has $(A_{jt}, e^1_{jt}) = (A, e)$. We assume that the probability of being a saver is $1/2$, suggesting that half of the consumers receive $(1, 1)$ and the others are borrowers.[2] Note that it also means that consumer j may be a saver with a probability of $1/2$ in each period.

In the afternoon, consumer j consumes c^2_{jt} units of consumption and pays one unit of real money balances to each unit of loan if she borrowed money in the morning. Consumer j also buys government bonds at the money price of q_t in period t, to be redeemed in period $t + 1$ for one unit of money, so that $i_t = (1 - q_t)/q_t$ is the nominal interest rate. Thus, the afternoon budget constraint is

$$c^2_{jt} + q_t(1 + \pi_t)b_{jt+1} + (1 + \pi_t)m_{jt+1} + \tau_{jt} = b_{jt} + m_{jt} + z_{jt} + e^2_{jt}$$

where b_{jt} is real government bond holdings, B_{jt}/P_t, τ_{jt} is real lump-sum taxes, e^2_{jt} is the afternoon endowment and is the same for all j, and $\pi_t = (P_{t+1} - P_t)/P_t$ is the inflation rate during period t.

[2] We can certainly assume other probabilities such as, for example, ω and $1 - \omega$. However, considering the effects of the relative number of savers (borrowers) is not pursued in this paper.

Solving the morning budget constraint for z_{jt} and substituting into the afternoon budget constraint, we obtain the period-t budget constraint. The period-t integrated budget constraint can be written as

$$c_{jt}^2 + \frac{c_{jt}^1 - e_{jt}^1}{\theta_t} + q_t(1+\pi_t)b_{jt+1} + (1+\pi_t)m_{jt+1} + \tau_{jt} = b_{jt} + m_{jt} + e_{jt}^2. \tag{8}$$

The financial friction is introduced by assuming that the household faces a ceiling on how much it can borrow in the private loan market in the morning. We assume that only a fraction $\delta \in [0, 1]$ of the household's bond holdings can be used as collateral in the private loan market in the morning, and we consider δ to be part of the fiscal policy tools. The borrowing constraint can thus be written as

$$-z_{jt} = \frac{c_{jt}^1 - e_{jt}^1}{\theta_t} \leq \delta b_{jt}. \tag{9}$$

Finally, the government's budget constraint during period t (in nominal terms) is given by

$$q_t B_{t+1} + S_t + M_{t+1} = B_t + M_t \tag{10}$$

where $B_t = \int_0^1 B_{jt} dj$ is the nominal debt inherited from period $t-1$ and S_t the nominal primary surplus during period t; $S_t = T_t - G_t$, where $T_t = \int_0^1 T_{jt} dj$ is nominal lump-sum tax revenue, G_t nominal government purchases, and $M_t = \int_0^1 M_{jt} dj$ denotes nominal money balances.

3.2 Equilibrium

The consumer's problem is

$$\max_{\left\{c_{jt}^1, c_{jt}^2, b_{jt+1}, m_{jt+1}\right\}_{t=0}^{\infty}} E_{j0} \sum_{t=0}^{\infty} \beta^t u(c_{jt}^1, c_{jt}^2, m_{jt+1})$$

subject to the period-t integrated budget constraint (8) and the period-t borrowing constraint (9). The Lagrangian for this optimization problem is

$$\begin{aligned}
\mathcal{L} = E_{j0} \sum_{t=0}^{\infty} \beta^t \Bigg\{ & u(c_{jt}^1, c_{jt}^2, m_{jt+1}) \\
& + \lambda_{jt} \left[e_{jt}^2 + b_{jt} + m_{jt} - c_{jt}^2 - \frac{c_{jt}^1 - e_{jt}^1}{\theta_t} - q_t(1+\pi_t)b_{jt+1} - (1+\pi_t)m_{jt+1} - \tau_{jt} \right] \\
& + \mu_{jt} \left(\delta b_{jt} - \frac{c_{jt}^1 - e_{jt}^1}{\theta_t} \right) \Bigg\}
\end{aligned}$$

where λ_{jt} is the multiplier on the integrated budget constraint (8), representing the marginal utility of wealth, and μ_{jt} is the multiplier on the morning borrowing constraint (9), representing the shadow value of liquidity.

The first-order conditions with respect to c^1_{jt}, c^2_{jt}, b_{jt+1}, and m_{jt+1} are (respectively)

$$u_1(c^1_{jt}, c^2_{jt}, m_{jt+1}) - \lambda_{jt}\frac{1}{\theta_t} - \mu_{jt}\frac{1}{\theta_t} = 0 \tag{11}$$

$$u_2(c^1_{jt}, c^2_{jt}, m_{jt+1}) - \lambda_{jt} = 0 \tag{12}$$

$$-\lambda_{jt}(1+\pi_t)q_t + E_{jt}\beta\left(\lambda_{jt+1} + \delta\mu_{jt+1}\right) = 0 \tag{13}$$

$$u_3(c^1_{jt}, c^2_{jt}, m_{jt+1}) - \lambda_{jt}(1+\pi_t) + E_{jt}\beta\lambda_{jt+1} = 0. \tag{14}$$

In addition, there are two transversality conditions

$$\lim_{t\to\infty} \beta^t\lambda_{jt}q_t(1+\pi_t)b_{jt+1} = 0 \tag{15}$$

$$\lim_{t\to\infty} \beta^t\lambda_{jt}(1+\pi_t)m_{jt+1} = 0. \tag{16}$$

Conditions (8), (9), and (11)–(14) are necessary for a maximum while (8), (9), and (11)–(16) are jointly sufficient.

Following Angeletos et al. (2013), we are assuming that preferences are linear in afternoon consumption. This implies that any heterogeneity in afternoon income is absorbed by afternoon consumption so that every consumer has the same choice of savings. We then impose $b_{jt} = b_t$ for all j, which is without any loss of generality and optimality. According to our assumption, this economy can be simplified so that there are 50 % savers and 50 % borrowers in each period. Since a saver makes loans, her morning borrowing constraint (9) is not able to bind. However, a borrower's borrowing constraint binds. Therefore, borrowers and savers have different first order conditions with respect to their morning consumptions, and these first order conditions are

$$A\frac{1}{c^1_{\text{Borrower},t}} - \frac{1}{\theta_t} - \frac{1}{\theta_t}\mu_{\text{Borrower},t} = 0 \tag{17}$$

$$\frac{1}{c^1_{\text{Saver},t}} - \frac{1}{\theta_t} = 0. \tag{18}$$

Equilibrium in the morning loan market is then characterized by

$$-z_{\text{Borrower},t} = \frac{1}{2}\delta b_t \tag{19}$$

$$c^1_{\text{Borrower},t} + z_{\text{Borrower},t}\theta_t = \frac{1}{2}e \tag{20}$$

$$c^1_{\text{Saver},t} + z_{\text{Saver},t}\theta_t = \frac{1}{2} \tag{21}$$

$$-z_{\text{Borrower},t} = z_{\text{Saver},t} \tag{22}$$

and Eqs. 17 and 18.

Equation 19 is the binding borrowing constraint of a borrower. Equations 20, 21, and 22 characterize the resource constraints in the morning. Equations 17 and 18 are the optimality conditions for the borrower and the saver.

The equilibrium in the morning loan market has a closed form solution as follows

$$c^1_{\text{Saver},t} = \frac{1}{2}\frac{1}{1+\frac{1}{2}\delta b_t} \tag{23}$$

$$c^1_{\text{Borrower},t} = \frac{1}{2}+\frac{1}{2}e-\frac{1}{2}\frac{1}{1+\frac{1}{2}\delta b_t} \tag{24}$$

$$\theta_t = \frac{1}{2}\frac{1}{1+\frac{1}{2}\delta b_t} \tag{25}$$

$$z_{\text{Borrower},t} = -\frac{1}{2}\delta b_t \tag{26}$$

$$z_{\text{Saver},t} = \frac{1}{2}\delta b_t \tag{27}$$

$$\mu_{\text{Borrower},t} = \frac{A-[(1+e)(1+\frac{1}{2}\delta b_t)-1]}{(1+e)(1+\frac{1}{2}\delta b_t)-1} \tag{28}$$

where we impose that $A > [(1+e)(1+\frac{1}{2}\delta b_t)-1]$ for avoiding a non-positive shadow value of liquidity.

Using asterisks to denote the equilibrium value of each variable in the morning loan market, then conditions (11)–(13) and the utility function (7) imply the following Euler equation, which is the same for savers and borrowers,

$$q_t = E_t\frac{P_t}{P_{t+1}}\beta\left(1+\frac{1}{2}\delta\mu^*_{t+1}\right). \tag{29}$$

Note that we drop the subscript j in Eq. 29, since all consumers have the same Euler equation. Plugging Eq. 29 into the government's budget constraint (10) yields

$$E_t\frac{P_t}{P_{t+1}}\beta\left(1+\frac{1}{2}\delta\mu^*_{t+1}\right)B_{t+1}+S_t+M_{t+1} = B_t+M_t$$

or, equivalently,

$$E_t\gamma_t b_{t+1}+\frac{M_{t+1}-M_t}{P_t}+s_t = b_t \tag{30}$$

where

$$\gamma_t = \beta\left(1+\frac{1}{2}\delta\mu^*_{t+1}\right) \tag{31}$$

and s_t is the real primary surplus, S_t/P_t. In fact, γ_t is the real price of government debt. Consumers will pay less for purchasing government debt if γ_t is close to zero.

4 Financial Frictions and the FTPL

We solve Eq. 30 forward to obtain

$$\begin{aligned}\frac{B_t}{P_t} &= s_t + E_t(1+\pi_t)m_{t+1} - m_t + E_t\sum_{i=0}^{\infty}\left(\prod_{j=0}^{i}\gamma_{t+j}s_{t+j+1}\right)\\ &\quad + E_t\sum_{k=0}^{\infty}\left\{\prod_{d=0}^{k}\gamma_{t+d}\left[m_{t+d+2}(1+\pi_{t+d+1}) - m_{t+d+1}\right]\right\}\\ &\quad + E_t\prod_{f=0}^{\infty}\gamma_{t+f}b_{t+f+1}.\end{aligned} \tag{32}$$

The transversality condition (15) requires the last term of Eq. 32 to be zero. It means that the present value of government debt is zero. Therefore, Eq. 32 is identical to

$$\begin{aligned}\frac{B_t}{P_t} &= s_t + E_t(1+\pi_t)m_{t+1} - m_t + E_t\sum_{i=0}^{\infty}\left(\prod_{j=0}^{i}\gamma_{t+j}s_{t+j+1}\right)\\ &\quad + E_t\sum_{k=0}^{\infty}\left\{\prod_{d=0}^{k}\gamma_{t+d}\left[m_{t+d+2}(1+\pi_{t+d+1}) - m_{t+d+1}\right]\right\}.\end{aligned} \tag{33}$$

Equation 33 is the basic fiscal theory of the price level. As B_t is determined before period t, the price level is related to government policy regarding the primary surplus. Any expected budget deficit increases the current price level, P_t. When the monetary authority keeps the nominal money supply constant, fiscal policy can be the sole determinant of the price level.

The highlight of this friction model is that the friction indicator, δ, determines the size of the expected monetary and fiscal policy effects on the price level. In other words, the financial friction affects the sensitivity of the price level to any policy that aims to affect it. For instance, the effect of an expected or announced budget deficit at time $t+1$ on the price level is related to γ_t. According to Eqs. 28 and 31, δ affects γ_t and changes the policy effects of $E_t s_{t+1}$. Moreover, δ can be considered as a determinant of the price level. Keeping other variables constant, any increase or decrease in δ will influence γ_t, and consequently the price level.

Does the financial friction have a monotonic effect on the price level? Let's have a look at the following equation

$$\frac{\partial\gamma_t}{\partial\delta} = \frac{1}{2}\beta\frac{Ae - \left(e^2 + e\delta b_{t+1} + e^2\delta b_{t+1}\right) - \left(\frac{1}{2}b_{t+1}\delta + \frac{1}{2}eb_{t+1}\delta\right)^2}{\left[(1+e)\left(1+\frac{1}{2}\delta b_{t+1}\right) - 1\right]^2}. \tag{34}$$

Since Eq. 34 does not have a clear sign, it is not straightforward to illustrate how changes in the financial friction affect the price level P_t and the friction indicator δ has an ambiguous effect on the price level. However, we can observe that Eq. 34 will be positive if the borrower's taste for morning consumption, A, is strong, holding other things constant. In other words, how much the borrower likes liquidity influences how the financial fiction affects the price level. We will discuss two types of borrower without loss of generality.

The first type of borrower has a strong taste for morning consumption so that she is crazy for liquidity. We call her the 'aggressive borrower.' In fact, $\partial\gamma_t/\partial\delta > 0$ is positive in the case of an aggressive borrower in each period. The second type of borrower has a weaker taste for morning consumption so that $\partial\gamma_t/\partial\delta < 0$ in each period. We call her the 'normal borrower.' It is important to note that we are not having these two types of borrowers simultaneously in our model, since A is a parameter. By assigning different values to A, determines which type of borrower we have and we will discuss these two possible types of borrower.

Increases in the friction indicator, δ, which reflect increases in pledged collateral, will enhance the policy effects, which are $\prod_{j=0}^{i}\gamma_{t+j}$ for $i \in N$, with an aggressive borrower. The financial friction can also affect the price level. In particular, the price level will decrease, if δ increases. The intuition is that a high collateral rate will initially increase γ_t, $t \in \mathbb{N}$, implying that the government will be paying less interest to all government debt holders. Note that the government can only make the interest payment by printing money, collecting real lump-sum taxes or issuing more real debt, which transfers the consumers's endowments to the government. Since the government needs to pay less in the case of an aggressive borrower, the government will print less money, collect less real taxes or issue less debt. In this case, the aggregate price level decreases.

Let's define leverage, l, as

$$l = \frac{\delta b^* + e^1_{\text{Borrower},t}}{e^1_{\text{Borrower},t}}$$

where $\delta b^* + e^1_{\text{Borrower},t}$ represents the borrower's total liquid assets in the morning and $e^1_{\text{Borrower},t}$ is the borrower's exogenous endowment. Clearly, a high collateral rate δ leads to an increase in leverage and allows the borrower to finance more consumption with the same endowment. Therefore, we can link the price level to this exogenous leverage ratio and conclude that increases in the exogenous leverage ratio l will reduce the price level, with an aggressive borrower.

In the case with the normal borrower

$$\frac{\partial \prod_{j=0}^{i}\gamma_{t+j}}{\partial\delta} < 0; \text{ for } i \in N.$$

In this case, increases in the friction indicator, δ, will harm the policy effects. Moreover, the price level will increase, if δ increases. The reason for this is that the government needs to pay more interest to all government debt holders, and the government will print more money, collect more real taxes or issue more debt.

4.1 The Inflation Rate

Equation 29 implies

$$1 + \pi_t = \gamma_t(1 + i_t). \tag{35}$$

Taking a logarithmic approximation of Eq. 35 and rearranging yields

$$i_t = -\log \gamma_t + \pi_t. \tag{36}$$

Equation 36 represents the Fisherian link between the nominal interest rate and the inflation rate. That is, $-\log \gamma_t$ is an approximation for the real interest rate. It also indicates that a higher collateral rate will reduce (raise) the real interest rate with the aggressive (normal) borrower. When monetary policy does not effectively stimulate the level of economic activity during anxious times (such as during the global financial crisis) and the economy has the aggressive borrower, policymakers can implement expansionary policies to raise the inflation rate and reduce the real interest rate by increasing the collateral rate.

Thus, monetary policy, as reflected by the nominal interest rate i_t, and fiscal policy, as reflected by the collateral rate δ, jointly determine the inflation rate, π_t. A zero inflation rate (that is, a constant price level) requires

$$i_t = \log \frac{1}{\gamma_t} \tag{37}$$

when the real interest rate is positive. The left hand side of Eq. 37 reflects monetary policy and the right hand side is partly controlled by the fiscal authority. It suggests that the monetary authority needs to set the nominal interest rate so that Eq. 37 holds for a given δ. Hence, coordination of monetary and fiscal policy is required to achieve price stability.

4.2 The Chicago Rule

The Chicago (or Friedman) rule regarding the socially optimal inflation rate requires that the economic agent is satiated with the transactions facilitating services of money

$$u_3(c^m_{jt}, c^a_{jt}, m_{jt+1}) = 0 \text{ for all } j \in \{\text{Saver, Borrower}\}.$$

Under the Chicago rule, the first-order condition (14) reduces to

$$\lambda_{jt}(1 + \pi_t) = E_{jt}\beta\lambda_{jt+1}. \tag{38}$$

Under the assumed utility function (7), Eq. 38 and the first-order conditions (12) and (13) imply

$$q_t = \frac{1}{1 + i_t} = 1 + E_t\delta\mu_{t+1}.$$

As the nominal interest rate, i_t, cannot be negative, the only possible solutions of the above equation are

$$\begin{aligned} i_t &= 0 \\ E_t\mu_{t+1} &= 0. \end{aligned}$$

This is the Chicago rule, requiring a nominal interest rate of zero. The new finding is that the Chicago rule renders the borrowing constraint (9) non-binding. The intuition is that sufficient money balances enable the borrower to finance the same or even a higher utility level without taking a loan and it is no longer necessary to borrow in the morning. Alternatively, no one will want to make a loan at a price of θ_t different than 1, when the nominal interest rate is zero. That is, the morning loan market does not exist when the Chicago rule holds.

With these conditions, the first-order condition (13) yields

$$q_t = E_t \beta \frac{P_t}{P_{t+1}} \tag{39}$$

and the government's nominal budget constraint (10) can be written as

$$E_t \beta \frac{B_{t+1}}{P_{t+1}} + \frac{M_{t+1} - M_t}{P_t} + s_t = \frac{B_t}{P_t}. \tag{40}$$

When the Chicago rule is expected or announced to apply every period, we can also solve Eq. 40 forward to obtain

$$\frac{B_t}{P_t} = E_t \sum_{j=0}^{\infty} \beta^j s_{t+j} + E_t \sum_{k=0}^{\infty} \beta^k \left[m_{t+k+1}(1 + \pi_{t+k}) - m_{t+k} \right]. \tag{41}$$

Since the Chicago rule is applied every period, we have

$$m_{t+d} = m^{\text{Chicago}} \text{ for all } d \in \mathbb{N}$$

and Eq. 41 yields

$$\frac{B_t}{P_t} = E_t \sum_{j=0}^{\infty} \beta^j s_{t+j} + E_t \sum_{k=0}^{\infty} \beta^k m^{\text{Chicago}} \pi_{t+k}. \tag{42}$$

Thus, if the monetary authority chooses the inflation rate according to the Chicago rule, the fiscal authority can always affect the price level according to the fiscalist argument with a guaranteed forward solution. In this case, however, the collateral rate has no effect on the price level, because the borrowing constraint is not binding. Moreover, because the inflation rate is also fixed to meet the requirement of a zero nominal interest rate if the real interest rate is constant, the monetary policy part in Eq. 42 is actually

$$E_t \sum_{k=0}^{\infty} \beta^k m^{\text{Chicago}} \pi_{t+k} = \frac{1}{1-\beta} m^{\text{Chicago}} \pi^{\text{Chicago}} = \text{ fixed number.}$$

It means that fiscal policy may determine the price level by itself when the Chicago rule is applied. The intuition is that the Chicago rule is a strict condition, giving almost no freedom to the monetary authority. In other words, monetary policy loses its ability to affect general economic variations, including the price level, and the role of fiscal policy is enhanced in order to solely determine the price level. This theoretical result provides an explanation as to why Fig. 3 shows evidence in support of the fiscal theory of the price level. The U.S. Federal Reserve has resorted to unconventional monetary policy (quantitative easing, long-term bond purchases, and managing expectations) to inject liquidity into the economy since 2008. Thus, fiscal policy plays an important role in determining the price level when the zero lower bound constraint on the policy rate is binding.

The fiscal policy not only determines the current price level P_t but also the price level path. Since $i_t = 0$, Eq. 39 implies $E_t P_{t+1} = \beta P_t$. Therefore, when the Chicago rule applies every period, we have $E_t P_{t+i} = \beta^i P_t$ for $i \in N$. It follows that the fiscal policy determines this path of deflation, which satisfies the Chicago rule, by affecting P_t.

5 'Active' and 'Passive' Policies

In this section, we investigate the implications of financial frictions in the context of 'active' and 'passive' monetary and fiscal policies, as in Leeper (1991). We impose a feasibility condition that the government keeps the real public debt constant at the level b^*.[3] It means $b_{t+1+i} = b^*$ for $i \in N$. This feasibility condition and Eq. 28 guarantee a constant shadow value of liquidity, so that $\mu_{t+1+i} = \mu^{\#}$ for $i \in N$.

The first order conditions (13) and (14), under the assumed utility function (7), yield

$$\frac{1}{R_t} = \beta\kappa \frac{1}{\Pi_t} \tag{43}$$

$$m_{t+1} = \frac{1}{\beta\left(\kappa R_t - 1\right)} \tag{44}$$

where $\Pi_t = 1 + \pi_t$, $\kappa = 1 + \frac{1}{2}\delta\mu^{\#}$, and $R_t \ (= 1 + i_t) = 1/q_t$.

As in Leeper (1991), we consider a class of rules suggested by actual policies. The monetary authority sets the gross nominal interest rate, R_t, as a function of the gross inflation rate

$$R_t = \varphi_0 + \varphi_1 \Pi_{t-1} + \varepsilon_t^R \tag{45}$$

where $\varphi_1 \Pi_{t-1}$ represents the systematic monetary policy response to economic conditions and ε_t^R is a random monetary policy shock. The fiscal authority sets the primary surplus, s_t, as a function of the level of the real government debt outstanding

$$s_t = \vartheta_0 + \vartheta_1 \psi_{t-1} + \varepsilon_t^s \tag{46}$$

where $\psi_{t-1} = B_t/P_{t-1}$, $\vartheta_1 \psi_{t-1}$ represents the systematic fiscal policy response to economic conditions, and ε_t^s is a random fiscal policy shock. It is assumed that the random shocks, ε_t^R and ε_t^s, follow an AR(1) process with zero mean and innovations that are serially and mutually uncorrelated. One may question the implication of our assumption that $b_t = b^*$ in each period in the context of the fiscal rule (46). It is straightforward to see that Eq. 46 is equivalent to

$$s_t = \vartheta_0 + \vartheta_1 b^* \Pi_{t-1} + \varepsilon_t^s. \tag{47}$$

Equation 47 implies that the fiscal authority sets the primary surplus, s_t, as a function of the gross inflation rate. Then the monetary authority and the fiscal authority both respond to inflation, and therefore our system of 'active' and 'passive' monetary and fiscal policies is significantly different from Leeper (1991).

[3] This assumption could lead to a discussion similar to that in McCallum (2001). McCallum (2001) assumes a constant real public debt path and show how the price level is determined by the fiscal policy.

Equations 43 and 45 imply

$$\Pi_t = \beta\kappa\varphi_0 + \beta\kappa\varphi_1\Pi_{t-1} + \beta\kappa\varepsilon_t^R. \tag{48}$$

Equations 44 and 46, together with the government's budget constraint (10), the latter written in real terms, yield

$$\frac{\psi_t}{R_t} + \vartheta_0 + \vartheta_1\psi_{t-1} + \varepsilon_t^s + \frac{\Pi_t}{\beta\left(\kappa R_t - 1\right)} = \frac{\psi_{t-1}}{\Pi_{t-1}} + \frac{1}{\beta\left(\kappa R_{t-1} - 1\right)}. \tag{49}$$

Taking a first-order Taylor series expansion of each of Eqs. 48 and 49 around stationary state values yields

$$\tilde{\Pi}_t = \phi_1\tilde{\Pi}_{t-1} + \phi_2\varepsilon_t^R \tag{50}$$

$$\tilde{\psi}_t = \&eta a_1\tilde{\psi}_{t-1} + \eta_2\tilde{\Pi}_{t-1} + \eta_3\tilde{\Pi}_{t-2} + \eta_4\varepsilon_t^R + \eta_5\varepsilon_{t-1}^R + \eta_6\varepsilon_t^s \tag{51}$$

where the tilde denotes deviation from the deterministic stationary state value,

$$\begin{aligned}
\phi_1 &= \beta\kappa\varphi_1; \quad \phi_2 = \beta\kappa; \\
\eta_1 &= \frac{1}{\beta\kappa} - \vartheta_1 R^*; \quad \eta_2 = \frac{\varphi_1\psi^*}{R^*} - \frac{\psi^*}{\beta\kappa\Pi^*} - \frac{\kappa\varphi_1 R^*}{(\kappa R^* - 1)} + \frac{\kappa\varphi_1 R^*\Pi^*}{\beta(\kappa R^* - 1)^2}; \\
\eta_3 &= -\frac{\kappa\varphi_1 R^*}{\beta(\kappa R^* - 1)^2}; \quad \eta_4 = \frac{\psi^*}{R^*} + \frac{\kappa R^*\Pi^*}{\beta(\kappa R^* - 1)^2} - \frac{\kappa R^*}{(\kappa R^* - 1)}; \\
\eta_5 &= -\frac{\kappa R^*}{\beta(\kappa R^* - 1)^2}; \quad \eta_6 = -R^*,
\end{aligned}$$

and R^*, Π^*, and ψ^* are the deterministic stationary state values of the gross nominal interest rate, the gross inflation rate, and the redefined real government debt. Equations 50 and 51 imply the following system

$$\begin{pmatrix} E_t\tilde{\psi}_t \\ E_t\tilde{\Pi}_t \\ E_t\tilde{\Pi}_{t-1} \end{pmatrix} = \begin{pmatrix} \eta_1 & \eta_2 & \eta_3 \\ 0 & \phi_1 & 0 \\ 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} \tilde{\psi}_{t-1} \\ \tilde{\Pi}_{t-1} \\ \tilde{\Pi}_{t-2} \end{pmatrix} + \begin{pmatrix} \eta_4 & \eta_5 & \eta_6 \\ \phi_2 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} \varepsilon_t^R \\ \varepsilon_{t-1}^R \\ \varepsilon_t^s \end{pmatrix} \tag{52}$$

which, according to Blanchard and Kahn (1980), for a unique equilibrium requires either of the following two scenarios

$$\text{Scenario 1}: |\eta_1| > 1 \text{ and } |\phi_1| < 1$$
$$\text{Scenario 2}: |\eta_1| < 1 \text{ and } |\phi_1| > 1.$$

Under scenario 1 fiscal policy is active ($|\eta_1| > 1$) and monetary policy is passive ($|\phi_1| < 1$). In this scenario the price level can be influenced by fiscal policy, because Eq. 51 is an unstable difference equation in real debt and monetary policy obeys the constraints imposed by private and fiscal policy behavior, allowing the money stock to respond to deficit shocks. Under scenario 2 fiscal policy is passive ($|\eta_1| < 1$) and monetary policy is active ($|\phi_1| > 1$), reacting strongly to inflation. In this scenario passive fiscal policy prevents an explosive path of government debt and active monetary policy stabilizes the price level by preventing deficit shocks from affecting the inflation rate. See Leeper (1991) for more details.

In our case, financial frictions play an important role in the equilibria. Let's consider the case of an aggressive borrower first. In particular, lower δ values render fiscal policy more active (since $\partial\eta_1/\partial\delta < 0$) and monetary policy more passive (since $\partial\phi_1/\partial\delta > 0$). This suggests that fiscal policy has a potential advantage in choosing the equilibria or restoring the equilibria. When, for example, each policy authority acts passively, there is price-level indeterminacy. In such a case, by reducing δ, fiscal policy can become active while monetary policy is still passive, leading to scenario 1 equilibria. If, however, the fiscal authority wants to help the monetary authority stabilize prices, increasing the collateral rate, δ, will lead to scenario 2 equilibria. In the case of a normal borrower, the fiscal authority will need to raise δ for scenario 1. On the other hand, scenario 2 requires a high δ.

The Taylor principle and the Chicago rule can also be addressed in the context of 'active' and 'passive' monetary and fiscal policies. For example, because a lower δ implies a lower ϕ_1 with the aggressive borrower, the monetary authority will have to raise ϕ_1 whenever δ declines in order to keep its policy active and commit to a nominal anchor. In this case, φ_1 will have to be greater and be big enough so that $\phi_1 > 1$. As the Chicago rule implies passive monetary policy, because the nominal interest rate is constant (at zero) over time, fiscal policy will be able to influence the price level under Scenario 1.

Finally, in the case of active monetary policy ($|\phi_1| > 1$), with passive fiscal policy and under the assumption that the random monetary policy shock, ε_t^R, follows an AR(1) process, as in Leeper (1991)

$$\varepsilon_t^R = \rho_1\varepsilon_{t-1}^R + \zeta_t^R$$

with $\zeta_t^R \sim N(0, 1)$ and $\rho_1 \in [-1, 1]$, we could solve Eq. 50 forward to get

$$\tilde{\Pi}_{t-1} = E_t\left(\frac{\Pi_{t-1+n}}{{\phi_1}^n} - \phi_2\sum_{a=1}^{n}\frac{1}{{\phi_1}^a}\varepsilon_{t+a-1}^R\right). \tag{53}$$

Using Eq. 48 into Eq. 53 yields

$$\tilde{\Pi}_{t-1} = -\phi_2\left(\frac{1}{\phi_1} + \frac{\rho_1}{{\phi_1}^2} + \frac{{\rho_1}^2}{{\phi_1}^3} + \cdots\right)\varepsilon_t^R \tag{54}$$

with $n \to \infty$. Since $|\varphi_1| > 1$ and $\rho_1 \in [-1, 1]$, Eq. 54 implies

$$\Pi_{t-1} = \frac{\beta\kappa}{\rho_1 - \varphi_1\beta\kappa}\varepsilon_t^R + \Pi^* \tag{55}$$

where Π^* is the steady state inflation rate. With an aggressive borrower, as $\partial\Pi_{t-1}/\partial\kappa > 0$ and $\partial\kappa/\partial\delta > 0$, in the case of a positive monetary shock, Eq. 55 implies that an increase in liquidity increases the inflation rate, a result consistent with the quantity theory of money. With a normal borrower, $\partial\kappa/\partial\delta < 0$ so that an increase in liquidity decreases the inflation rate. Therefore, an increase in liquidity might not be a sufficient condition for a high inflation rate in an economy with a borrowing constraint. As long as the liquidity demander (the borrower) has a moderate taste for liquidity, increasing the liquidity will reduce the price level.

Compared with the result in Leeper (1991), Eq. 55 shows that the equilibrium is determined by active monetary policy and passive fiscal policy. In particular, it suggests that the price level is determined jointly by monetary policy, φ_1, the monetary shock, ε_t^R, and fiscal policy, δ. Thus, fiscal policy has an important and complicated role to play in the determination of the price level.

6 Conclusion

In the aftermath of the global financial crisis, many central banks around the world have been implementing unconventional monetary policies in a zero lower bound environment. Moreover, many countries, including the United States, Japan, and a number of Euro area countries, are accumulating debt at alarming rates. As Sims (2013) argues, the macroeconomic effects of such policies cannot be investigated in the context of conventional macroeconomic models with non-interest-bearing base money, a money multiplier, and a tight relation between the price level and the quantity of money. The fiscal theory of the price level can successfully integrate monetary-fiscal policy interactions to explain the determination of the price level and also provide a framework for current policy discussions, including issues pertaining to the welfare cost of inflation — see Yavari and Serletis (2011) — and the spillover effects between policies — see, for example, Hallett and Libich (2007) and Hallett and Viegi (2002).

In this paper we take a tentative first pass at integrating discussion of the fiscal theory of the price level and financial frictions, arguing that financial frictions play an important role in determining the price level (and, hence, inflation and nominal interest rates). We provide an empirical investigation of the relevance of the fiscal theory of the price level, updating the Canzoneri et al. (2001) analysis and providing evidence that the non-Ricardian explanation is plausible when the zero lower bound constraint on the policy rate is binding. We then derive the theoretical implications of the fiscal theory of the price level, in the context of an optimal growth model with a borrowing constraint, and show that during anxious times (such as the global financial crisis and Great Recession that followed), collateral rates have significant effects on macroeconomic variations. Finally, in revisiting Leeper's (1991) equilibria under 'active' and 'passive' monetary and fiscal policies in a world with financial frictions, we show that fiscal policy has a potential advantage in choosing the equilibria or restoring the equilibria.

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