

# Leaning Against the Credit Cycle\*

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## Abstract

We study the interaction between monetary policy and debt dynamics. While conventional business cycle models with household debt and borrowing constraints typically assume that all debt is amortized within a quarter, we study an environment where debt is as gradually amortized as is typically observed. First, we show that with a realistically gradual amortization process, in contrast to conventional wisdom, the initial effect of a contractive monetary policy shock is to *increase* households' debt burden, as defined by the *real* stock of debt or the debt-to-income ratio. Monetary tightening is likely to reduce the debt burden only over a longer horizon, after the policy-effect on inflation and output has died out. Second, we show that the long term nature of debt generates credit cycles that are highly persistent, similar to what the BIS and others have recently emphasized. As long as monetary policy does not respond to debt movements, the long term nature of debt is of limited importance for macroeconomic variables other than debt itself. Third, while responding to debt and responding to inflation in a simple interest rate rule are close substitutes when all debt is amortized each quarter, a positive response coefficient on debt can be destabilizing with long-term debt, and requires a stronger response to inflation in order to avoid equilibrium indeterminacy. Fourth, we study the consequences of extending the monetary policy objectives from emphasizing just inflation and output, to also aiming for debt stability, under optimal policy. If all debt is assumed to be amortized within a quarter, then credit stabilization primarily causes higher inflation volatility. In contrast, when amortization is as gradual as with a standard 30-year mortgage contract, leaning against credit movements shifts the frontier of feasible outcomes toward higher output volatility.

**Keywords:** Monetary policy, credit, long-term debt

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# 1 Introduction

Credit typically moves in a gradual manner, giving rise to the term *credit cycle* (Aikman, Haldane, and Nelson, 2013). However, standard macroeconomic models fail to account for this regularity. In a nutshell, because all debt is renegotiated each period, debt moves swiftly in response to shocks and policy changes. This empirical failure is problematic for two reasons. First, if there are feedback effects between debt dynamics and other macroeconomic variables, as financial frictions might imply, failure to account for debt dynamics might be detrimental for our capacity to understand the macroeconomy. Second, in the current policy debate central questions regards how monetary and macroprudential policy should respond to movements in household debt. These questions cannot be adequately addressed in frameworks that are incapable of replicating the essential features of debt dynamics.

For the above reasons, we develop a dynamic stochastic general equilibrium where household debt is amortized only gradually. Within this environment, we explore the joint dynamics of debt and other macroeconomic variables, and answer our overriding question: How should policy deal with the low-frequent credit cycle?

To model multiperiod debt within a DSGE model suitable for policy analysis, we rely on the contracting framework proposed by (Kydland, Rupert and Sustek, 2012). Here the amortization rate of debt, constantly at one in standard 1-period debt models, follows a process calibrated to match the properties of a standard mortgage contract. With an amortization structure resembling a 30-year mortgage contract, our model produces debt dynamics that are highly persistent, reminiscent of the credit cycle. While there is feedback between debt and the macroeconomy via a collateral constraint relating new loans to property value, other macroeconomic variables than debt move faster, and revert far earlier to steady state than debt does after shocks. In this sense, our framework succeeds in capturing the coexistence of a low-frequent credit cycle together with a conventional business cycle.

Because only new loans respond on impact, monetary policy shocks cause only a moderate reduction of nominal debt. Inflation and output, however, respond faster. Hence, real debt and debt-to-income both *rise* in the first quarters after a monetary policy shock. However, as inflation and output return to steady state while the initial reduction of new nominal loans is not overturned before a long time has passed, both the real debt level and debt-to-income contract below their steady state levels some time after the shock, and then return to steady state only after a considerable period. With a 30-year debt contract, it takes approximately 20 years before real debt has reverted entirely back to its steady state after a monetary policy shock.

When we consider systematic monetary policy, we find that it can be detrimental to mechanically lean against these low-frequent credit movements. With policy characterized by a simple interest rule, only a moderate positive response coefficient to debt induces equilibrium indetermi-

nacy. If the interest rate is set optimally to minimize a loss function over inflation and output, the consequences of introducing debt stabilization to these target variables are very different under long-term rather than 1-quarter debt. In the latter case, leaning against credit movements causes higher inflation volatility, but leaves output variation largely unchanged. With 30-year debt, leaning against the persistent credit swings now causes more volatility of output.

Section 2 presents our model, emphasizing particularly the amortization schedule. Section 3 discusses how long term debt alters the transmission of monetary policy shocks to households' debt burden, and the the model's capacity to provide a realistically persistent credit cycle. Section 4 discusses the consequences of conducting monetary policy with an eye to stabilize debt, emphasizing how these policy implications are affected by the speed with which households amortize their mortgages.

## 2 Basic Model

We consider a standard New Keynesian Dynamic Stochastic General Equilibrium model with household debt and collateral constraints, similar to that of Iacoviello (2005). The novelty of our framework is to allow for long-term mortgage debt.

### 2.1 Households

The economy is populated by two types of households: *patient* (indexed by  $j = 1$ ) and *impatient* (indexed by  $j = 2$ ), of mass  $1 - n$  and  $n$ , respectively. Impatient households have a lower subjective discount factor ( $\beta_2 < \beta_1$ ) which generates an incentive for them to borrow.

Households derive utility from a flow of consumption  $c_{j,t}$  and services from housing  $h_{j,t}$ . They derive disutility from labor  $L_{j,t}$ . Each household maximizes

$$E_{j,t} \sum_{t=0}^{\infty} \beta_j^t \left\{ \log(c_{j,t} - bc_{j,t-1}) + \nu_{j,h} \log(h_{j,t}) - \nu_{j,L} \frac{L_{j,t}^{1+\varphi_L}}{1+\varphi_L} \right\}, \quad (1)$$

The parameter  $b$  governs the importance of habit formation in utility, where  $c_{j,t-1}$  is a reference level of consumption which the household takes into account when formulating its optimal consumption plan. The parameter  $\nu_{j,h}$  governs the utility from housing services,  $\nu_{j,L}$  governs the disutility of labor supply, and  $\varphi_L$  governs the elasticity of labor supply. The total housing stock is fixed such that  $(1 - n)h_{1,t} + nh_{2,t} = 1$  for all  $t$

### Impatient Households

Borrowers face the following budget constraint:

$$c_{2,t} + q_t h_t + \frac{r_{t-1} + \delta_{t-1}^A}{\pi_t} b_{2,t-1} = w_t L_{2,t} + q_t h_{t-1} + l_t \quad (2)$$

where  $r_{t-1}$  is the nominal interest rate at the end of period  $t - 1$ ,  $\pi_t \equiv P_t/P_{t-1}$  is the gross inflation rate during period  $t$ ,  $w_t$  is the real wage,  $q_t$  is the real price of housing, and  $b_{2,t}$  is the borrower's real debt at the end of period  $t$ . Moreover,  $\delta_t^A$  is the amortization rate and  $l_t$  is new loans.

Real debt evolves according to

$$b_{2,t} = (1 - \delta_{t-1}^A) \frac{b_{2,t-1}}{\pi_t} + l_t. \quad (3)$$

The distinguishing feature of our analysis is to allow for  $\delta_t^A \leq 1$ . Our approach here is to follow Kydland, Rupert, Sustek (2012), and specify a process for the amortization rate that can be calibrated to match the properties of a typical annuity loan. The amortization rate evolves as follows:

$$\delta_t^A = \left(1 - \frac{l_t}{b_{2,t}}\right) (\delta_{t-1}^A)^{\alpha^A} + \frac{l_t}{b_{2,t}} (1 - \alpha^A)^{\kappa^A} \quad (4)$$

where  $\alpha \in [0, 1)$  and  $\kappa > 0$  are parameters and  $l_t^A/b_{2,t}$  represents the share of new loans in the end-of-period outstanding stock of debt. When  $\alpha = 0$ , we have  $\delta_t = 1$  for all  $t$  from (4) and  $l_t = b_t$  from (3), such that we recover a 1-period mortgage contract where all outstanding debt is repaid each period. When  $\alpha > 0$ , the above law of motion captures the realistic feature that the amortization rate is low during the early years of a mortgage (i.e., when mortgage payments consist mainly of interest) but the amortization rate rises during later years as more and more principal is repaid. Kydland et al (2012) show that appropriate settings for the parameters  $\alpha$  and  $\kappa$  can approximately match the amortization schedule of a typical 30-year mortgage. By combining (4) and (3), we can express the law of motion for amortization in terms of the stock of debt only:

$$\delta_t^A = (1 - \alpha^A)^{\kappa^A} + \frac{b_{2,t-1}}{\pi_t b_{2,t}} (1 - \delta_{t-1}^A) \left[ (\delta_{t-1}^A)^{\alpha^A} - (1 - \alpha^A)^{\kappa^A} \right]$$

By combining (2) and (3), we arrive at the conventional formulation of the borrowing constraint

$$c_{2,t} + q_t(h_{2,t} - h_{2,t-1}) = w_t L_{2,t} + b_{2,t} - \frac{R_{t-1}}{\pi_t} b_{2,t-1}$$

Hence, the introduction of long-term debt does not change the nature of the budget constraint. The reason why the amortization may still matter in our model, is the existence of a borrowing constraint. As in the literature on household debt following Iacoviello (2005), we assume that borrowing is constrained by the collateral value of borrower's housing stock. However, because we allow for an amortization rate below unity, we must distinguish between new loans  $l_t$  and the entire stock of debt  $b_t$  in the borrowing constraint. Logically, a large part of the economy's debt stock is given by decisions made in the past, and will not be directly influenced by the

borrowing constraint today. Instead, the constraint in any given period can only apply to new loans  $l_t$ . The collateral constraint is then

$$l_t^A \leq m_t \left[ \frac{E_{1,t} [q_{t+1} \pi_{t+1}] h_{2,t}}{R_t} - b_{2,t} \right],$$

expressing that new loans cannot exceed a fraction  $m_t$  of households' net worth. Combined with the law of motion for debt in (3), the constraint can be expressed in terms of debt rather than loans, as

$$b_{2,t} = \frac{m_t}{1+m_t} \frac{\widehat{E}_{1,t} [q_{t+1} \pi_{t+1}] h_{2,t}}{R_t} + \frac{1-\delta_{t-1}^A}{1+m_t} \frac{b_{2,t-1}}{\pi_t}. \quad (5)$$

We see that if all debt is amortized within one quarter, that is if  $\delta_t^A = 1$ , then the constraint collapses to the conventional formulation of Kiyotaki and Moore (1997) and Iacoviello (2005), where the current stock of debt is determined by collateral value only,  $\frac{m_t}{1+m_t}$  and is the loan-to-value ratio. In contrast, if debt is longer-lasting, i.e. if  $\delta_t^A < 1$ , the current stock of debt is constrained by existing debt as well, as it is only the last period's loans that are constrained by the current period's collateral value.

The time  $t$  Lagrangian of the impatient household is

$$\begin{aligned} \mathcal{L}_t = & \beta_2^t [U_t(c_{2,t}, h_{2,t}, L_{2,t})] + \\ & \beta_2^t \lambda_t \left\{ w_t L_{2,t} + b_{2,t} - c_{2,t} + q_t (h_{2,t-1} - h_{2,t}) - \frac{b_{2,t-1} R_{t-1}}{\pi_t} \right\} + \\ & \beta_2^t \lambda_t \mu_t \left[ \frac{m_t}{1+m_t} \frac{\widehat{E}_{1,t} [q_{t+1} \pi_{t+1}] h_{2,t}}{R_t} + \frac{1-\delta_{t-1}^A}{1+m_t} \frac{b_{2,t-1}}{\pi_t} - b_{2,t} \right] + \\ & \beta_2^t \lambda_t \eta_t \left\{ (1-\alpha^A)^{\kappa^A} + \frac{b_{2,t-1}}{\pi_t b_{2,t}} (1-\delta_{t-1}^A) \left[ (\delta_{t-1}^A)^{\alpha^A} - (1-\alpha^A)^{\kappa^A} \right] - \delta_t^A \right\} \end{aligned}$$

The impatient household's optimal choices are characterized by the following first-order conditions for  $L_{2,t}$ ,  $h_{2,t}$ , :

$$-U_{L_{2,t}} = U_{c_{2,t}} w_t, \quad (6)$$

$$U_{h_{2,t}} - U_{c_{2,t}} q_t + \beta_2 U_{c_{2,t}} \mu_t \frac{m_t}{1+m_t} \frac{E_t [q_{t+1} \pi_{t+1}]}{R_t} + \beta_2 U_{c_{2,t+1}} q_{t+1} = 0 \quad (7)$$

$$\begin{aligned} 0 = & U_{c_{2,t}} - \beta_2 E_t \left[ \frac{U_{c_{2,t+1}}}{\pi_{t+1}} \right] R_t - U_{c_{2,t}} \mu_t + \beta_2 E_t \left[ \frac{U_{c_{2,t+1}} \mu_{t+1}}{(1+m_{t+1}) \pi_{t+1}} \right] (1-\delta_t^A) - \\ & U_{c_{2,t}} \eta_t \frac{b_{2,t-1}}{\pi_t (b_{2,t})^2} (1-\delta_{t-1}^A) \left[ (\delta_{t-1}^A)^{\alpha^A} - (1-\alpha^A)^{\kappa^A} \right] + \\ & \beta_2 E_t \left[ \frac{U_{c_{2,t+1}} \eta_{t+1}}{\pi_{t+1}} \right] \frac{1}{b_{2,t+1}} (1-\delta_t^A) \left[ (\delta_t^A)^{\alpha^A} - (1-\alpha^A)^{\kappa^A} \right] \end{aligned} \quad (8)$$

$$\begin{aligned}
0 = & -U_{c_{2,t}}\eta_t - \beta_2 E_t \left[ \frac{U_{c_{2,t+1}}\mu_{t+1}}{(1+m_{t+1})\pi_{t+1}} \right] b_{2,t} + \\
& \beta_2 E_t \left[ \frac{U_{c_{2,t+1}}\eta_{t+1}}{\pi_{t+1}b_{2,t+1}} \right] b_{2,t} \left[ \alpha^A (\delta_t^A)^{(\alpha^A-1)} (1-\delta_t^A) - (\delta_t^A)^{\alpha^A} + (1-\alpha^A)^{\kappa^A} \right] \quad (9)
\end{aligned}$$

where  $\mu_t$  is the Lagrange multiplier associated with the borrowing constraint.

### Patient Households

Patient households lend to the borrowers. They also choose how much to consume, work, invest in housing, and invest in physical capital  $k_t$  which is rented to firms at the rate  $r_t^k$ . They receive the firm's profits  $\phi_t$ . The budget constraint of the patient household is given by:

$$c_{1,t} + I_t + q_t(h_{1,t} - h_{1,t-1}) + \frac{b_{1,t-1}R_{t-1}}{\pi_t} = b_{1,t} + w_t L_{1,t} + r_t^k k_{t-1} + \phi_t, \quad (10)$$

where  $(1-n)b_{1,t-1} = -nb_{2,t-1}$ . In other words, the aggregate bonds of patient households correspond to the aggregate loans of impatient households.

The law of motion for physical capital is given by:

$$k_t = (1-\delta)k_{t-1} + \underbrace{\left[1 - \frac{\psi}{2} (I_t/I_{t-1} - 1)^2\right]}_{S(I_t/I_{t-1})} I_t, \quad (11)$$

where  $\delta$  is the depreciation rate and the function  $S(I_t/I_{t-1})$  reflects investment adjustment costs. In steady state  $S(\cdot) = S'(\cdot) = 0$  and  $S''(\cdot) > 0$ .

The patient household's optimal choices are characterized by the following first-order conditions:

$$-U_{L_{1,t}} = U_{c_{1,t}} w_t, \quad (12)$$

$$U_{c_{1,t}} = \beta_1 R_t E_{1,t} \left[ \frac{U_{c_{1,t+1}}}{\pi_{t+1}} \right], \quad (13)$$

$$U_{c_{1,t}} q_t = U_{h_{1,t}} + \beta_1 E_{1,t} [U_{c_{1,t+1}} q_{t+1}], \quad (14)$$

$$U_{c_{1,t}} q_t^k = \beta_1 E_{1,t} \left\{ U_{c_{1,t+1}} \left[ q_{t+1}^k (1-\delta) + r_{t+1}^k \right] \right\}, \quad (15)$$

$$U_{c_{1,t}} = U_{c_{1,t}} q_t^k \left[ 1 - S\left(\frac{I_t}{I_{t-1}}\right) - \frac{I_t}{I_{t-1}} S'\left(\frac{I_t}{I_{t-1}}\right) \right] + \left(\frac{I_t}{I_{t-1}}\right)^2 \beta_1 \widehat{E}_{1,t} \left[ U_{c_{1,t+1}} q_{t+1}^k S'\left(\frac{I_{t+1}}{I_t}\right) \right], \quad (16)$$

where the last two equations represent the optimal choices of  $k_t$  and  $I_t$ , respectively. The symbol  $q_t^k \equiv v_t/U_{c_{1,t}}$  is the marginal value of installed capital with respect to consumption, where  $v_t$  is the Lagrange multiplier associated with the capital law of motion (11). We interpret  $q_t^k$  as the market value of claims to physical capital, i.e., the stock price.

## 2.2 Firms and Price Setting

Firms are owned by the patient households. We therefore assume that the subjective expectations of firms are formulated in the same way as their owners.

**Final Good Production.** There is a unique final good  $y_t$  that is produced using the following constant returns-to-scale technology:

$$y_t = \left[ \int_0^1 y_t(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}, \quad i \in [0, 1], \quad (17)$$

where the inputs are a continuum of intermediate goods  $y_t(i)$  and  $\theta > 1$  is the constant elasticity-of-substitution across goods. The price of each intermediate good  $P_t(i)$  is taken as given by the firms. Cost minimization implies the following demand function for each good  $y_t(i) = [P_t(i)/P_t]^{-\theta} y_t$ , where the price index for the intermediate good is given by  $P_t = \left[ \int_0^1 P_t(i)^{1-\theta} di \right]^{1/(1-\theta)}$ .

**Intermediate Good Production.** In the wholesale sector, there is a continuum of firms indexed by  $i \in [0, 1]$  and owned by patient households. Intermediate goods-producing firms act in a monopolistic market and produce  $y_t(i)$  units of each intermediate good  $i$  using  $L_t(i) = (1-n)L_{1,t}(i) + nL_{2,t}(i)$  units of labor, according to the following constant returns-to-scale technology:

$$y_t(i) = \exp(z_t) k_t(i)^\alpha L_t(i)^{1-\alpha}, \quad (18)$$

where  $z_t$  is an AR(1) productivity shock.

We assume that intermediate firms adjust the price of their differentiated goods following the Calvo (1983) model of staggered price setting. Prices are adjusted with probability  $1 - \theta_\pi$  every period, leading to the following New Keynesian Phillips curve:

$$\log\left(\frac{P_t}{P_{t-1}}\right) - \iota_\pi \log\left(\frac{P_{t-1}}{P_{t-2}}\right) = \beta_1 \left[ E_{1,t} \log\left(\frac{P_{t+1}}{P_t}\right) - \iota_\pi \log\left(\frac{P_t}{P_{t-1}}\right) \right] + \kappa_\pi \log\left(\frac{mc_t}{mc}\right) + u_t \quad (19)$$

where  $\kappa_\pi \equiv (1 - \theta_\pi)(1 - \beta\theta_\pi)/\theta_\pi$  and  $\iota_\pi$  is the indexation parameter that governs the automatic price adjustment of non-optimizing firms. Variables without time subscripts represent steady-state values. The variable  $mc_t$  represents the marginal cost of production and  $u_t$  is an AR(1) cost-push shock. Cost minimization implies the following expression for marginal cost

$$mc_t = \exp(-z_t) \left( \frac{w_t}{1-\alpha} \right)^{1-\alpha} \left( \frac{r_t^k}{\alpha} \right)^\alpha. \quad (20)$$

## 2.3 Monetary Policy

In the baseline model, we assume that the central bank follows a simple Taylor-type rule of the form:

$$R_t = (1+r) \left( \frac{\pi_t}{1} \right)^{\phi_\pi} \left( \frac{y_t}{y} \right)^{\phi_y} s_t, \quad (21)$$

where  $R_t$  is the gross nominal interest rate,  $r = 1/\beta_1 - 1$  is the steady-state real interest rate,  $\pi_t \equiv P_t/P_{t-1}$  is the gross inflation rate,  $y_t/y$  is the proportional output gap, and  $\varsigma_t$  is an AR(1) monetary policy shock.

In the policy experiments, we consider the following generalized policy rule that allows for a direct response to the stock of debt:

$$R_t = (1 + r) \left(\frac{\pi_t}{1}\right)^{\phi_\pi} \left(\frac{y_t}{y}\right)^{\phi_y} \left(\frac{b_{2,t}}{b}\right)^{\phi_b} \varsigma_t, \quad (22)$$

## 2.4 Calibration

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## 3 Monetary Policy Shocks and the Credit Cycle

In this section we analyze how the duration of debt influences the effects of a monetary policy shock and the cyclical behavior of the key variables in our model.

### 3.1 Does an Interest Rate Hike Increase the Debt Burden?

Does a hike in the policy rate reduce households' debt burden? The conventional view is that it will, as households faced by higher interest rates will choose to increase their borrowing by less than if interest rates were low. However, as pointed out by Svensson (2013), the answer is far from obvious once one acknowledges two important factors. First, household debt tends to be long-term, and only a limited fraction of the population adjust their stock of debt in any given period. Second, the burden of debt depends not only on the stock of nominal debt itself, but rather the stock of debt relative to the price level, or relative to income. Hence, if a sufficiently small fraction of debt is sensitive to interest rate changes, while output and inflation respond sufficiently strongly, the debt burden might well increase, rather than decrease when monetary policy is tightened. Ultimately then, the qualitative question of whether tighter policy increases the debt burden is best addressed within a quantitative model .

Figure 3.1 shows the impulse responses to a one standard deviation shock to monetary policy in our model. The solid line displays the effects when all debt is amortized each quarter ( $\delta_t = 1$ ). The dashed line displays the effects when the amortization rate evolves as if all debt was of 30-year maturity. We see that the dynamics of inflation, output and house prices are largely unaffected by the debt structure. However, the dynamics of the debt burden, measured either as the stock of real debt or as debt-to-output, differs starkly. With one-quarter debt, real debt,  $B_t$ , in the model, falls sharply on impact and thereafter returns gradually to its steady state level. Qualitatively, this behavior is consistent with the conventional view that a policy tightening reduces the debt burden. In sharp contrast, with 30-year debt the debt burden



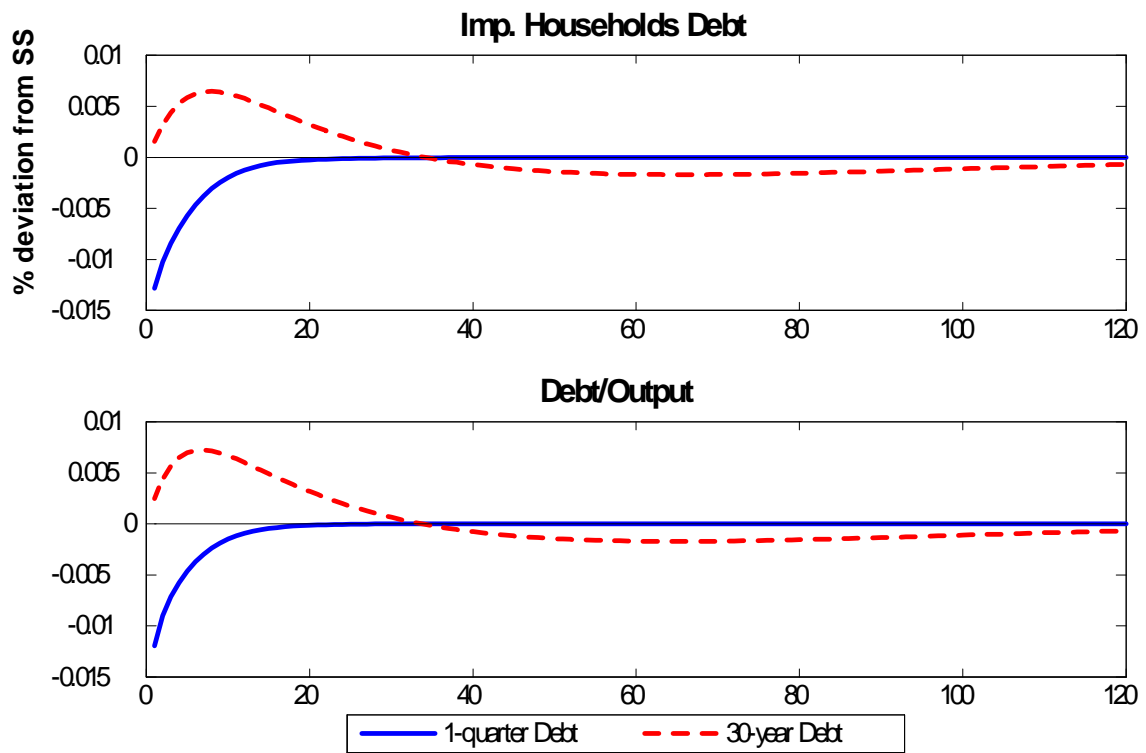
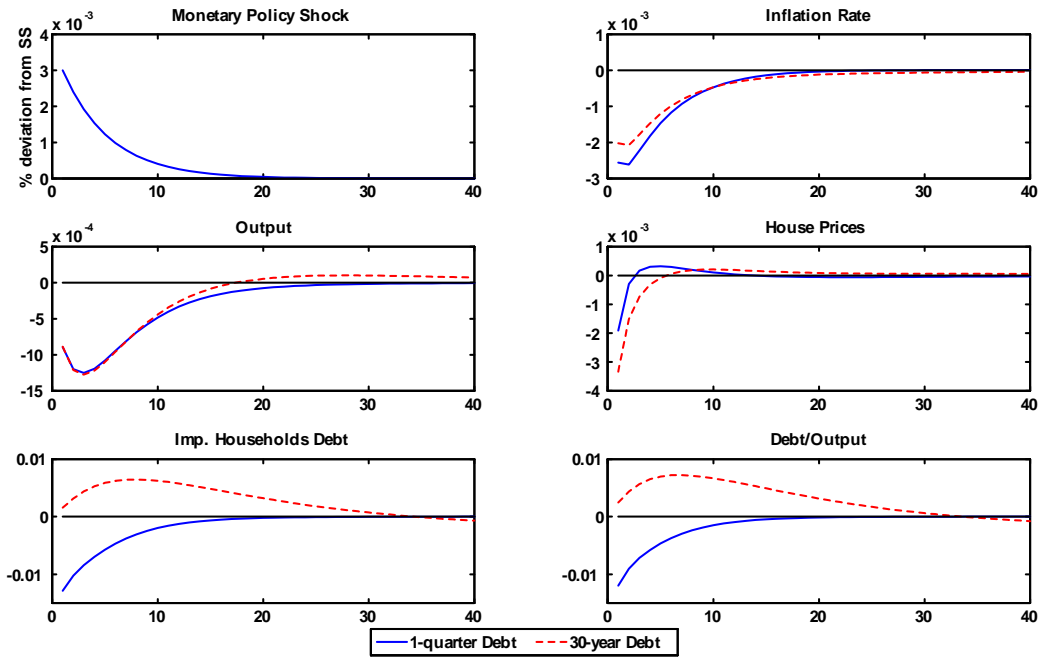
displays a hump-shaped *increase*. On impact, real debt hardly moves, but it thereafter rises gradually to a peak response of approximately 0.8 percent after 2 years. It thereafter falls very slowly, and approaches its steady state value after about 30 quarters. Importantly though, the debt burden does not stabilize here, but instead it drops below its steady state level for an extended period. Figure 3.1 therefore displays the responses of the debt burden over a longer horizon. We there see that debt stays moderately below its state level for approximately 30 years. In short, we see that while monetary tightening increases the debt burden in the short run, it decreases the debt burden slightly at a longer horizon.

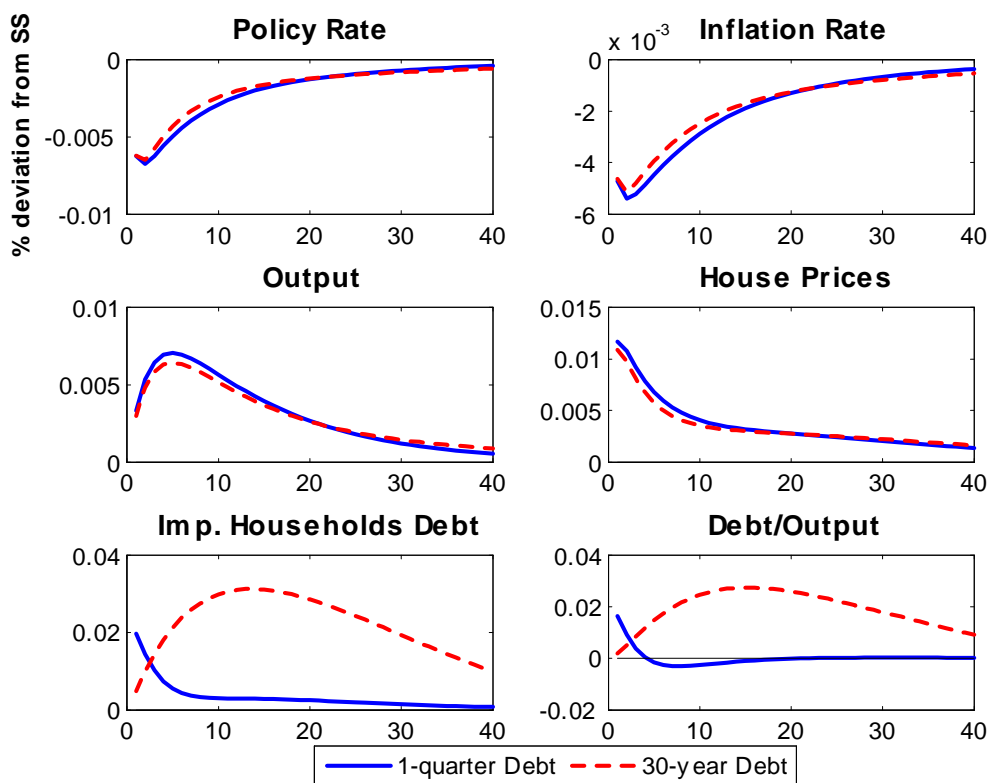
What explains the dynamics of debt under the 30-year amortization profile? It is here useful to consider the responses of inflation and output. With 30-year amortization, debt becomes highly persistent, as revealed by equation (5). Hence, on impact real debt and debt-to-income are both largely driven by the responses of output and inflation. The fall in these two variables tend to increase the debt burden. However, since house prices fall, fewer new loans will be issued. Because the initial drop in house prices is relatively strong, this force counteracts the influence of reduced inflation and output. As house prices revert faster than output and inflation, the debt burden gradually builds up. The peak response of debt is reached when house prices are back to steady state. Thereafter, as inflation and output revert to steady state, the debt burden also falls. However, after the effects on the other variables have died out, the total debt stock keeps falling. The reason is the initial contraction in new loans. This contraction, although modest enough to be dominated by output and inflation dynamics in the short run, has long-lived effects due to the long-term nature of debt. Hence, when the other macroeconomic variables have settled down to steady state, the initial contraction in new loans causes a moderate fall in the aggregate debt burden.

With regard to the question of how monetary policy affects the aggregate debt burden, we thus see that the answer depends on the horizon one has in mind. Consistently with the back-of-the-envelope calculation of Svensson (2013), and in contrast to the conventional view, we find that tighter policy increases the debt burden in the short run. In the intermediate run, though, monetary tightening causes a mild, but prolonged reduction of the debt burden.

### 3.2 The Persistent Credit Cycle

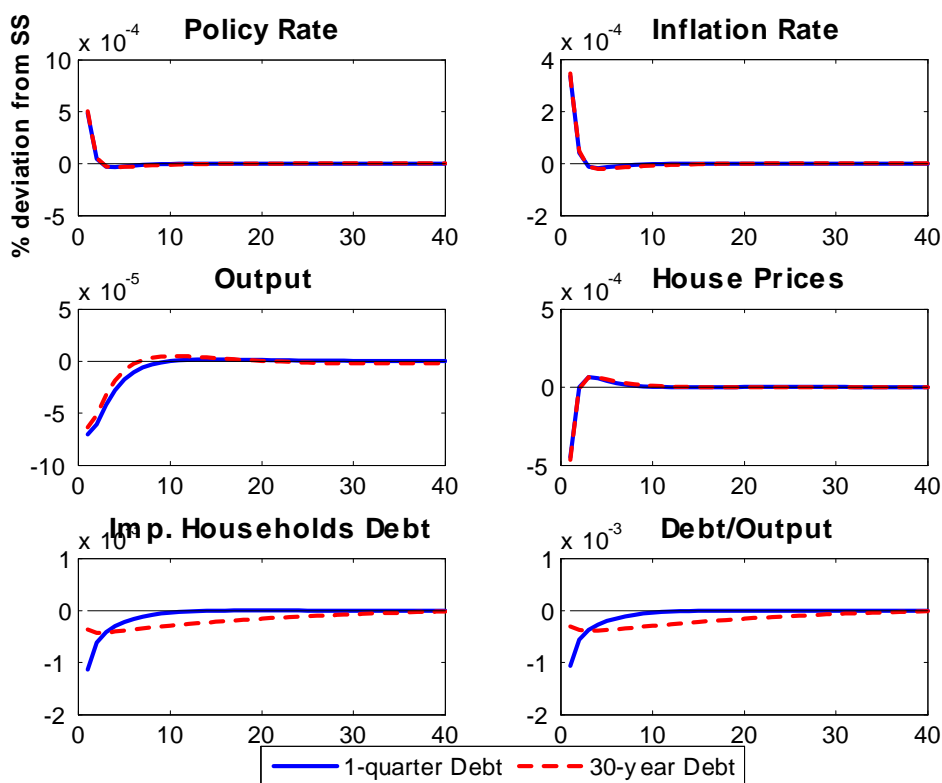
In order to further gauge the importance of capturing the long-term nature of household debt, Figures 3.2 and 3.2 display the key responses to productivity and mark-up shocks. Again we see that the duration to which we calibrate the amortization process does not affect the response of output, inflation and houseprices. However, we do see a markedly different response of both real debt and debt-to-output. Figure 3.2 reveals that debt responds positively to a tfp-shock both with one-quarter and 30-year debt, but that debt builds up more gradually in the latter case. Moreover, the peak response with long-term debt, reached after about 3 years, is greater





than the maximum response with one-quarter debt, occurring on impact. As with the monetary policy shock, we see that the close link between house prices and aggregate debt that occurs via the collateral constraint under 1-quarter debt is broken once only part of the debt is amortized every period. When the interest rate falls and house prices rise, more new loans are issued, and this effect accumulates over some time so that debt peaks far later than the monetary stimulus and house prices do. A similar logic applies to the cost push shock in Figure 3.2, where house prices drop since policy is tightened. Again the debt burden responds mutedly on impact, and with a hump-shaped highly persistent pattern.

Recently, several studies have characterized the cyclical properties of credit. A broad finding there is that one of the defining properties of the credit cycle is its high persistence. We therefore subject our model to the three shocks studied above, and simulate it over an extended period. The simulated trajectories of our model's variables are displayed in Figure 3.2, with a 1-quarter and a 30-year amortization process. First, as expected from the impulse responses before, we see that the amortization process has next to no effect on the behavior of output or inflation, and consequently no effect on the interest rate either. In contrast, the movements of real debt now differ considerably with the assumed amortization process. With 30-year debt, fluctuations are much more persistent, and of far greater amplitude. Hence, our model seems at least



qualitatively to capture the property that credit cycles move at a low frequency.<sup>1</sup>

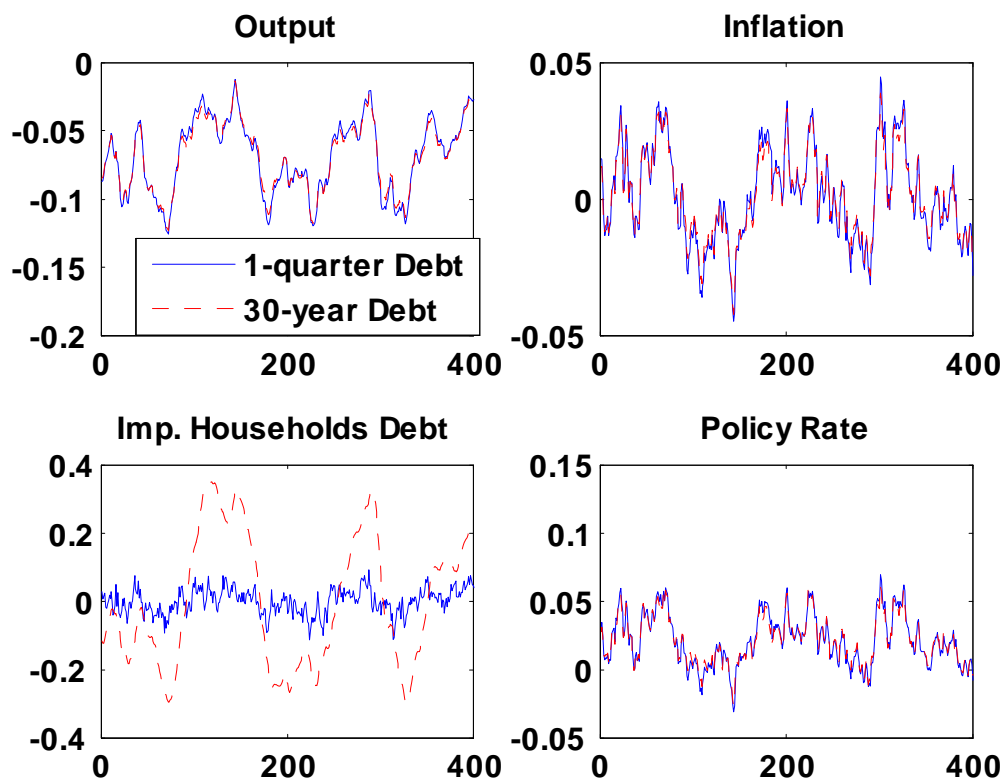
## 4 Monetary Policy Implications

We now turn to the question of how the long-term nature of household debt matters for the systematic conduct of monetary policy. More specifically, we aim to understand how systematic monetary policy reactions to curb credit swings affects the economy. We address the question from two angles. First, we study the consequences of responding to debt via a simple interest rate rule. Thereafter, we consider optimal policy, as conducted with the objective to stabilize conventional delegated target variables such as inflation, output, and potentially debt.

### 4.1 Simple Rules and Equilibrium Determinacy

A well-established guideline for monetary policy rules is that they must satisfy the "Taylor principle" if they are to stabilize the economy (e.g. Woodford, 2000). The Taylor principle states that the nominal interest rate must react more than one-for-one to changes in inflation.

<sup>1</sup>Moreover, if we contrast the HP-filtered series of output and credit, our model is also consistent with the claim that the cyclical deviations of credit from trend are longer than those of real activity. Following the literature on the credit cycle studies, e.g. blabla, the output series is filtered through an HP-filter with  $\lambda = 1600$ , and debt series is filtered  $\lambda = 400000$ .

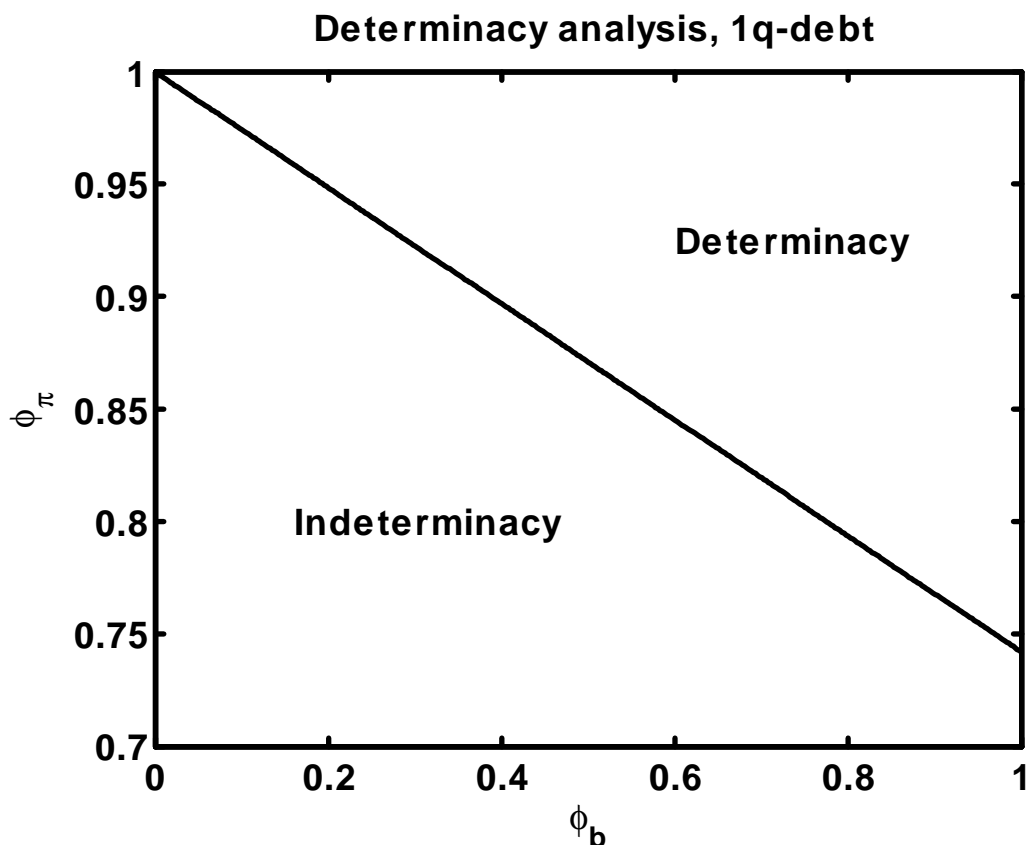


If this principle is not satisfied, expectations of higher inflation might turn self-fulfilling, as increased inflation expectations raise actual inflation and thereby lower the real interest rate in the absence of a sufficient monetary policy response. Hence, in terms of the policy rule specified in equation (22), the constraint from the Taylor principle is that  $\phi_\pi > 1$ , if the other response coefficients are set to zero. If the other coefficients are non-zero, the critical coefficient on inflation will typically vary, so as to ensure that the ultimate response to inflation is greater than one. For instance, numerous studies have explored how the joint response to output and inflation together determine the scope for equilibrium (in-)determinacy. In our setting, it is therefore natural to ask how systematic responses to debt in addition to inflation, alter the scope for equilibrium indeterminacy.

Figure 4.1 plots the determinacy region in the  $(\phi_\pi, \phi_b)$ -space. When  $\phi_b = 0$ , the critical value for the inflation coefficient is one, as we would expect from the Taylor principle. However, when policy starts responding to deviations of debt from its steady state, the required inflation coefficient drops. This pattern implies that in terms of ensuring equilibrium determinacy, responding to inflation and responding to debt are substitutes, because sunspot shocks move inflation and debt in the same direction. To understand why, consider the effects of a non-fundamentally motivated increase in inflation expectations. Through the forward-looking phillips curve, actual inflation increases too. Hence the real interest rate drops. From the borrowing constraint with  $\delta_t = 1$ , we see that the debt level increases as well. Hence, debt moves in the same direction as inflation, and a positive interest rate response to debt has the same stabilizing properties as responding to inflation.

Next, we consider the effects of extending the horizon over which debt is amortized. Figures 4.1 and 4.1 plot the determinacy regions under 15 and 30 year debt amortization profiles respectively. We see that now the relationship between the required debt and inflation responses is increasing, oppositely of the 1-quarter debt case. Intuitively, this occurs because an expectations driven increase in activity no longer drives the stock of real debt in the same direction as inflation. If inflation expectations rise without fundamentals to justify it, the inflationary pressure this generates will reduce the real debt stock. A positive value of response  $\phi_b$  will then in itself push nominal interest rate down, making the real interest rate fall even further. To counteract this destabilizing force, the response to inflation,  $\phi_\pi$ , must be greater the larger is  $\phi_b$ . The relationship between the critical values of  $\phi_\pi$  and  $\phi_b$  is steeper, the longer is the horizon over which the debt is amortized.

Finally, we also see that with 15-year debt, there is an intermediate region of  $(\phi_\pi, \phi_b)$ -combinations over which the equilibrium is determinate. For instance, if  $\phi_b = 0.4$ , we see that when  $\phi_\pi$  is around 1.8, the equilibrium is determinate, while a slightly higher response to inflation, say  $\phi_\pi = 2$ , leads to indeterminacy again. Though hardly visible in Figure 4.1, such an intermediate region also exists under 30-year debt, but for a very small range of  $\phi_b$ -values. This



intermediate region is similar to that which can be generated by capital investments if prices are sufficiently sticky, as emphasized by Sveen and Winke (2005) and Benhabib and Eusepi (2005). However, while intriguing, this region seems of little practical relevance in our case, as it is narrow.

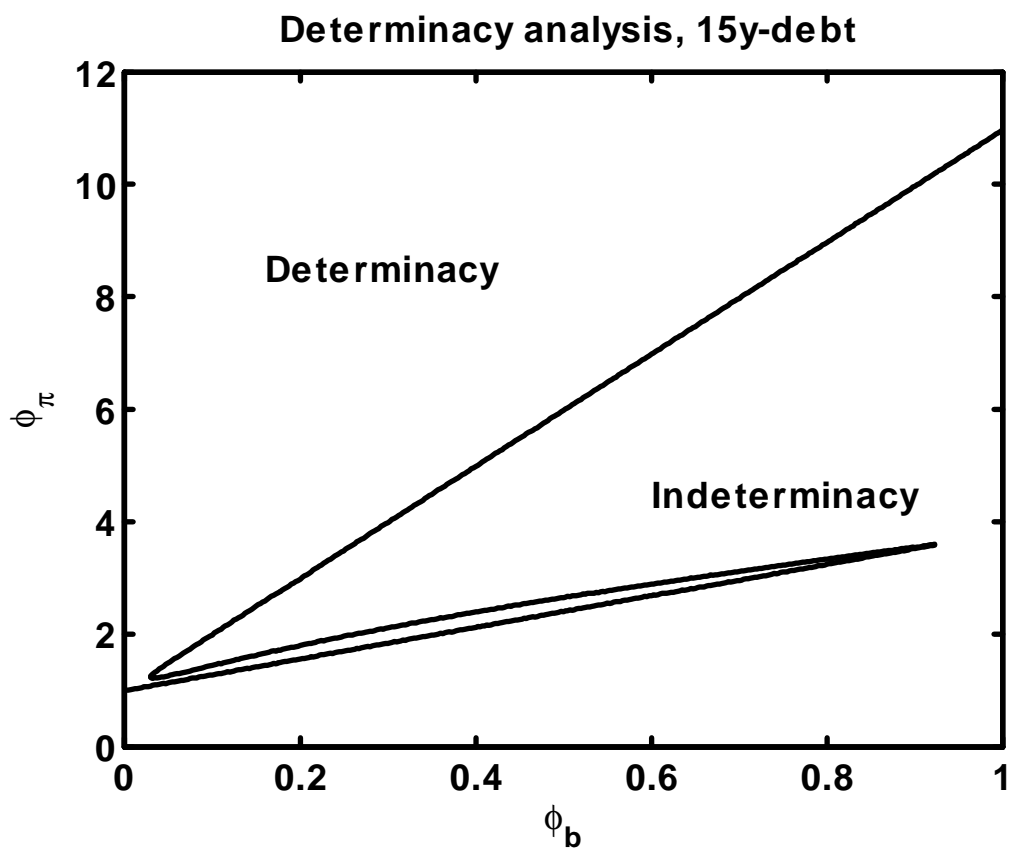
## 4.2 Debt Stabilization and Policy Tradeoffs

We now turn to the question of how an ambition to stabilize debt influences a central bank's ability to reach its more traditional objectives of inflation and output stabilization as well. As before, the low-frequency nature of the credit cycle will be at the centre of our attention.

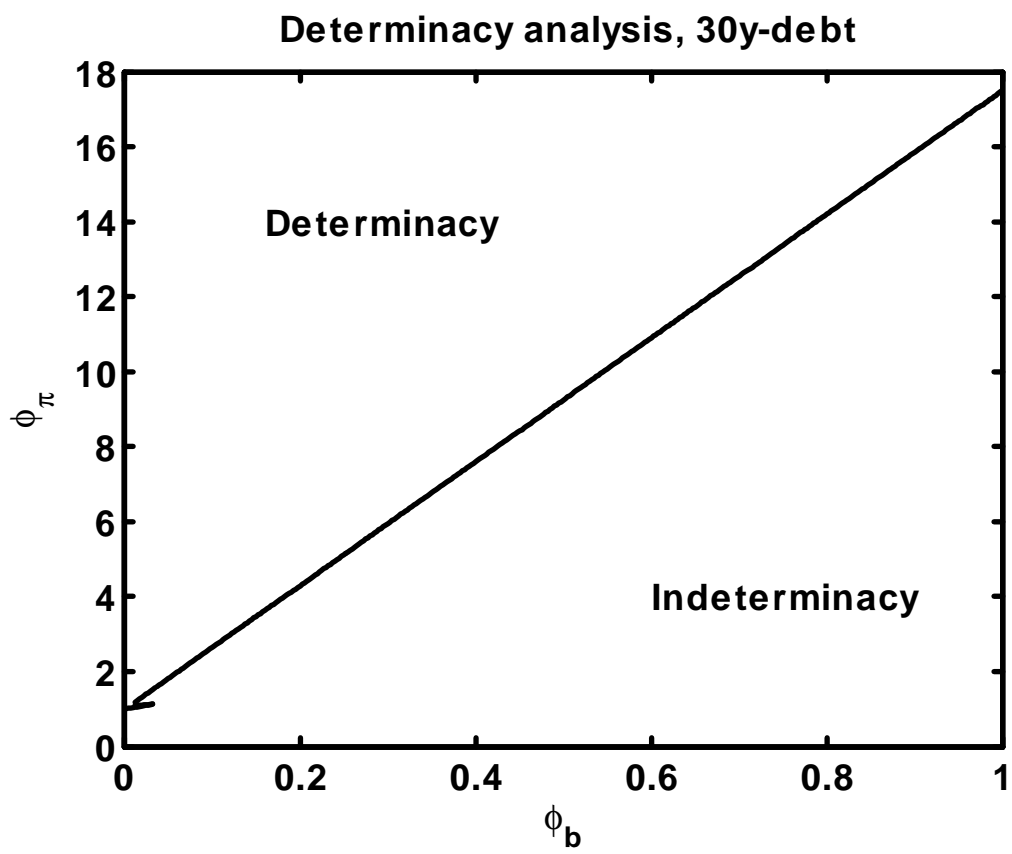
Rather than assuming that policy follows a simple rule, we here need to study the best feasible policy outcomes under an assigned objective function. Hence, we study the outcomes when monetary policy is set to minimize the following loss function:

$$L_t = var(\pi) + \lambda_y var(y) + \lambda_b var(b)$$

The policymaker is assumed to minimize  $L_t$  with respect to the interest rate,  $r_t$ , subject to the constraints imposed by the equilibrium conditions of the model. We assume that the policy







maker has the ability to commit. the economy is subjected to productivity and cost-push shocks, with standard deviations as in the benchmark calibration.

Figure 4.2 plots the trade-off between output gap and inflation stabilization, and how the feasible outcomes for these conventional target variables are affected by the additional aim to stabilize debt. Each curve plots output and inflation variances obtained under optimal policy with different weights,  $\lambda_y$ , on output. The blue solid curve plots this efficiency frontier with 1-quarter debt and  $\lambda_b = 0$ , and the blue dashed curve plots the frontier with a positive weight,  $\lambda_b = 0.5$ , on debt. Similarly, the two red curves plot the frontiers with 30-year debt, for  $\lambda_b = 0$  and  $\lambda_b = 0.5$ .

The main insight from the figure is that the horizon over which debt is amortized, determines whether the efficiency frontier shifts toward greater inflation or output volatility. If all debt is amortized each period, the efficiency frontier shifts horizontally, implying that the additional concern for debt volatility primarily leads to higher variance of inflation. For instance, when the policymaker does not care about activity, so  $\lambda_y = 0$ , introducing a preference for debt stabilization raises the variance of inflation from almost zero to 1, whereas output variance falls. In contrast, when the amortization process fits the 30-year schedule, the efficiency frontier moves toward higher output variance but only a limited increase in the variance of inflation. For the case with  $\lambda_y = 0$ , we see that the variance of inflation increases from zero to approximately 0.2 if the policymaker starts emphasizing debt. Differently from the 1-quarter case, output volatility, in contrast increases somewhat too.

The underlying mechanism behind the shifts of the efficiency frontiers is again closely related to the persistence of credit, and to how it affects the monetary policy transmission mechanism. With the 1-quarter amortization process, we saw that monetary policy moves real debt, inflation and output all in the same direction. Hence, debt stabilization impedes inflation and output stabilization if the shocks to the economy move these two variables in opposite direction. From Figures 3 we know that a positive productivity shock increases both output and debt, whereas inflation falls. Hence, increased emphasis on debt stabilization implies greater inflation volatility in the 1-quarter debt case. With 30-year debt,

## 5 Conclusion

## References

Aikman, David, Haldane, Andrew G. and Nelson, Benjamin D. 2014 . “Curbing the Credit Cycle.” *The Economic Journal*.

Kydland Finn E., Peter Rupert and Roman Sustek. 2012. “Housing Dynamics over the Business Cycle.” NBER Working Papers no. 18432.

$$L_t = \pi_t + \lambda_y Y_t + \lambda_B B_t$$

