Financial Repression in General Equilibrium*

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Abstract

Financial repression allows governments to borrow at artificially low interest rates. Quantifying financial repression is challenging, because it relies on an estimate of the interest rate which would prevail in the absence of repression—a counterfactual outcome. In this paper, we put forward a quantitative business cycle model which features financial repression. In the model the government can reduce the return on government debt as it requires banks to hold a certain fraction of their assets as government debt. Repression distorts financial intermediation and lowers banks' profits and net worth. As banks are leverage constrained, they restrict lending and economic activity declines in response to financial repression. We estimate the model on US times series for the period 1948–1974 in order to quantify the extent of financial repression and its impact on the economy.

Keywords: Financial repression, government debt, interest rates, Financial intermediation, Bayesian Estimation

JEL-Codes: H63, E43, G28

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1 Introduction

Financial repression allows governments to borrow at artificially low interest rates. This may be the result of explicit or implicit ceilings on nominal interest rates or other measures. It requires that investors are somehow held captive through capital controls or regulatory policies (McKinnon, 1973; Shaw, 1973). While financial repression has traditionally been considered a phenomenon specific to developing economies, Reinhart and Sbrancia (2015) argue—based on institutional details and the observation that real interest rates have been low and often even negative—that financial repression has also been pervasive in many advanced economies during the period after WW2. Figure 1 provides suggestive evidence as it displays times series of US real interest rates after WW2. The data show that the yield on longer-term US government debt (solid line) has been relatively low until the late 1970s. In particular, long-term yields were not systematically higher than the short-term interest rate (dashed line) in the first half of the sample.[1]

In this paper, we seek to quantify the extent of financial repression in the US during the post-WW2 period—both in terms of its effects on interest rates and in term of its contribution to the sizeable "liquidation of government debt" during that period. Moreover, we ask how financial repression affected the macroeconomic performance of the US economy during that period. This question is pertinent given the rather spectacular build-up of public debt in many advanced economies during recent years. In many instances, the ratio of debt-to-GDP has by now reached or even surpassed the debt levels observed at the end of WW2. It is conceivable that, as with previous episodes, financial repression may feature prominently in the mix of debt-reduction policies (Reinhart, 2012). Given poor growth prospects and low inflation, financial repression has the benefit—at least from a political-economy point of view—that it works stealthier than austerity policies. It may also be less disruptive than outright default.[2]

Quantifying the extent of repression is challenging, because the interest rate which would prevail in the absence of repression—say the "laissez-faire" interest rate—is not directly observable.[3] Earlier studies focused on developing countries. In this case one may proxy the laissez-faire interest rate with the interest rate a government pays on world capital markets, as suggested by Giovannini and de Melo (1993). They document that the "repression tax" contributed handsomely to government revenues.[4] An earlier survey by Fry (1997) concludes that financial repression contributed to government revenue in the order of 2 percent of GDP in a sample of developing economies. In their study on 12 advanced economies Reinhart and Sbrancia (2015) find that the savings of annual interest-rate expenses amounted to up to 5 percent. This result

[1]A similar picture emerges for nominal interest rates. The average interest rate on 10-year government bonds during 1960–1974, for instance, is very similar to average federal funds rate: 5.4 vs 5.2 percent. Instead, during 1980–2005 average long-term nominal rates were considerably higher, also vis-à-vis short term rates: 7.7 vs 6.5 percent (source: St. Louis Fed/FRED).

[2]Reinhart, Reinhart, and Rogoff (2015) survey a menu of options for debt reduction which includes financial repression.

[3]The laissez-faire interest rate as defined in this paper will generally differ from the natural rate of interest which would prevails if prices and wages are flexible. In a flex-price world, for instance, there may still be repression which pushes the actual (and hence the natural) rate below the laissez-faire rate.

[4]Giovannini and de Melo (1993) investigate 24 countries during the period 1972–1987. They find several instances in which the annual amount of "revenue" that is due to financial repression amounts to 5 percent of GDP.

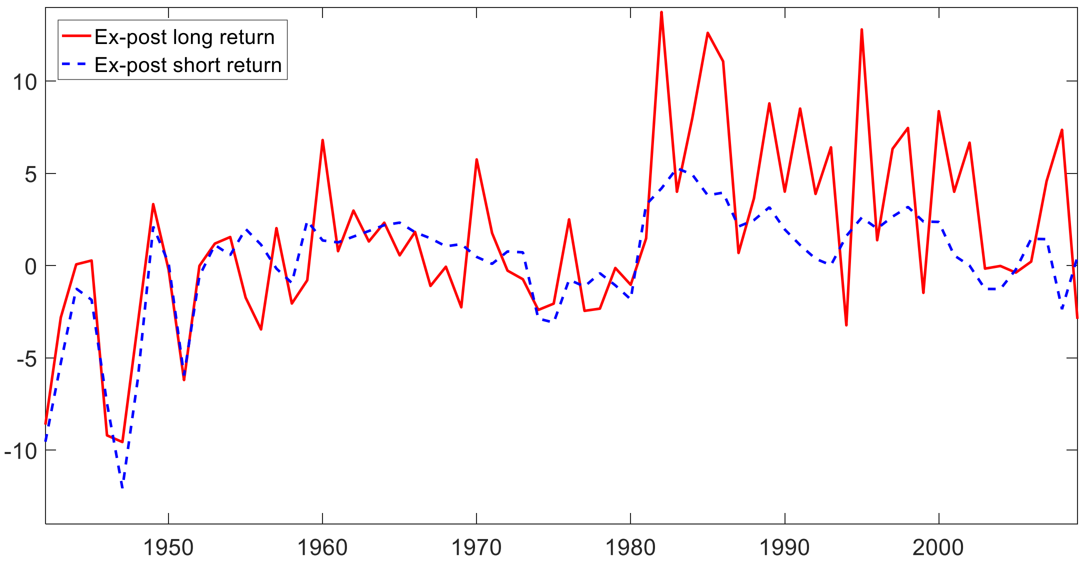

Figure 1: Real interest rates (ex post): solid line is return on marketable debt of government portfolio computed by Hall and Sargent (2011); dashed line is three month T-bill rate minus actual inflation (source: St. Louis Fed).

assumes a constant, repression-free interest rate in the range between 1 and 3 percent.

In our analysis we rely on a dynamic general equilibrium model in order a) to estimate of the laissez-faire interest rate and b) to study the general equilibrium effects of repression through counterfactual experiments. Our model is a conventional New Keynesian business cycle model which features leverage-constrained banks as in Gertler and Karadi (2011, 2013). The essential feature of our model is an additional constraint under which banks operate. Specifically, we follow Chari, Dovis, and Kehoe (2016) and assume that banks face a "regulatory constraint" which requires them to hold a certain fraction of their assets as government debt. As governments vary this fraction they effectively alter the yield on long term government debt. Our setup thus makes explicit that the banking sector is a captive audience for government debt. In practise, the regulatory constraint reflects a variety of measures on which the government may rely, if only unintendedly, when it auctions off its debt at elevated prices.

In the model, the government issues long-term debt only, which is held either by households or banks. Our focus on long-term government debt is motivated the evidence shown in Figure 1, but also by narrative accounts of financial repression. First, in the late 1940s, the Fed, according to chairman Eccles, allowed short rates to fluctuate, but maintained a ceiling of 2.5% for the long-term rate (Chandler, 1949). This ceiling on the return of long-term debt kept to be a concern during the negotiations of the Fed Accord in 1951 which made the Federal Reserve less dependent of the Treasury. At the time the Treasury exchanged a large amount of long-term non-marketable debt for marketable debt in order to further keep long-term interest rates low (Hetzel and Leach, 2001). Similarly, during the early 1960s, the US government conducted "operation twist" in order to raise short-term rates (to attract foreign capital inflows) while keeping long-term rates low.

In our model, households can adjust short-term bank deposits freely. However, as in Gertler and Karadi (2013) we assume that households face transaction costs when they adjust their holdings of government debt. In equilibrium the yield on long-term debt differs from short-term interest rates on deposit because of two distinct factors. First, because banks are leverage constrained they are unable to arbitrage away yield differences between short- and long-term rates. A tighter leverage constraint because of, say, reduced net worth, raises, all else equal, the difference between short-term and long-term rates. This difference can be interpreted as a term premium due to market segmentation (Fuerst, 2015). Second, financial repression, all else equal, reduces long-term yields and hence tends to offset the term premium.

Against this background, we observe that the actual evolution of short and long-term interest rates is consistent with the predictions of our model—under the maintained hypothesis that financial repression was more pervasive in the post-WW2 period compared to the post-1970s. The model rationalize the observation that short and long-term rates differed hardly during the repression period because it predicts that repression offset the term premium.[5]

Because in our analysis financial repression operates along the yield curve, it is consistent with the notion that government debt carries a "convenience yield" (Krishnamurthy and Vissing-Jorgensen, 2012). Importantly, the convenience yield reflects investors' preference for liquid and safe assets rather than regulatory measures. However, Krishnamurthy and Vissing-Jorgensen (2012) find that the yield spreads between non-government and government debt are equally responsive to the supply of government debt in case of short and long-term debt. Also, recent estimates of the convenience yield by Del Negro et al. (2017) focus on a trend that is "common across maturities".

Through financial repression the government effectively taxes the financial sector. This is consequential for the economy at large, because banks are special in their ability to monitor firms. As in Gertler and Karadi's original formulation we assume that all savings of households are channeled through banks in order to fund investment projects. As repression distorts banks' portfolio choice and reduces their net worth, investment is crowded out and output and inflation decline. We also contrast financial repression with conventional monetary policy measures such as a cut in the short-term policy rate. Repression and conventional monetary policy may have a similar impact on public finances. Yet, monetary policy differs from financial repression or regulation in general in that it impacts short and long term real interest rates alike: "it gets in all the cracks" (Stein, 2013). More importantly still, we also show that repression and conventional monetary policy transmit through the economy in profoundly different ways.

We estimate the model on quarterly US time series data for the period 1948–1974. Our estimation is based on eight macroeconomic variables and, in addition, two financial variables, namely equity returns and banks' net worth. We find that the model performs well. In particular the models' prediction for the share of government debt in banks' portfolio aligns very well with actual developments, even though those have not been considered in the estimation.

Turning to the issue at hand, we also use the model to compute the laissez-faire interest rate. It is considerably higher than actual rates, except for a few instances. However, the interest rate reduction varies considerably over time. Next we quantify the contribution financial repression to the reduction of public debt during our sample period. We do this in two ways. First, we

[5] Estimates of the term premium (which do not account for repression) also tend to show a strong increase of the term premium after the 1970s (Adrian, Crump, and Moench, 2015).

take an accounting perspective and compute the counterfactual evolution of debt assuming the government had paid the laissez-faire rather than the actual interest rate, keeping all else equal. We find that in the case the debt ratio would have declined by 35 rather than by 60 percentage points.

In a second experiment, we account for general equilibrium effects. Once we do that, we find that without repression the debt-to-output ratio would have declined much faster than in case of repression. Intuitively, this is because in the absence of repression the economy would have been on a more expansionary trajectory. With financial intermediation less impaired, we observe an investment boom in our counterfactual scenario. Also consumption and output are increased relative to the actual developments. As a consequence, inflation is also higher in the counterfactual scenario. These observations can explain why the debt ratio declines faster. In this sense, repression was not contributing to the liquidation of government debt at all. In our view, this finding is particularly noteworthy given the conventional view that repression is part toolkit to bring about a reduction of government. We find the conventional view confirmed merely from an accounting point of view.

A number of recent contributions are exploring different aspects of financial repression. Our model builds on Chari, Dovis, and Kehoe (2016), notably as we rely on their regulatory constraint. Just like them our modelling of the banking sector is based on Gertler and Karadi (2011). However, they abstract from nominal rigidities and the conduct of monetary policy. Instead, they focus on the optimality of financial repression in a world where governments lack commitment to paying back its debt and may thus default on its liabilities. Importantly, they show that under commitment a repression tax is inferior to directly taxing banks' assets because financial repression distorts not only banks' asset holdings but also their portfolio decision. Our analysis, instead, is purely positive as it seeks to quantify the contribution of the repression tax to debt reduction and to explore counterfactual outcomes.

Roubini and Sala-i-Martin (1995) put forward a model where financial repression raises money demand, say because of regulation that limits use of checks, ATMs etc. This in turn raises the base on which the inflation tax operates. As result, their model predicts that inflation and financial repression go hand in hand, quite contrary to what our analysis suggests (see also Brock, 1989). There is also recent empirical work which suggests that repression has been under way during the recent euro area crisis (Becker and Ivashina, 2016; Ongena, Popov, and Van Horen, 2016). More generally, financial regulation has been found to impact financial markets. Du, Tepper, and Verdelhan (2018), for instance, rationalize large and persistent deviations from covered interest rates in light of the new regulatory environment put in place after the crisis. it seems to impair the ability of financial intermediaries to carry out arbitrage away spreads between the return of riskless securities. This mechanism operates at the heart of our model.

The remainder of the paper is structured as follows. Section 2 outlines the model and explains how financial repression works in our model Section 3 describes our data, the estimation as well as the choice of our priors. It also presents results. We answer the main questions in Section 4 as we quantify financial repression and compute counterfactual. A final section offers a short conclusion.

2 The Model

Our analysis is based on a medium-scale New Keynesian model in which the financial sector takes center state. Here our analysis builds on earlier work of Gertler and Karadi (2011, 2013) and Chari, Dovis, and Kehoe (2016). As we estimate the model in Section 3, we require it to be sufficiently rich to capture the dynamics of actual time-series data. In this regard we build on earlier work by Bianchi and Ilut (2016), notably as far as the fiscal sector is concerned, and on Justiniano, Primiceri, and Tambalotti (2013). The economy is populated by four types of agents: households, banks, firms and a government. We discuss their decision problems in some detail below.

2.1 Households

There is a continuum of identical households which consume, save and supply labor to an employment agency. As in Gertler and Karadi (2011, 2013), a fraction f of household members are bankers and a fraction $1-f$ are workers. Workers are employed by an intermediate good firm and earn wage income. Bankers manage a financial intermediary, which collects deposits from all households and funds non-financial firms and holds government bonds. There is perfect consumption smoothing within the household. Over time, each member may change its occupation, yet the fraction of household members in each occupation remains constant. In particular, with probability $1-\sigma$ a banker quits and becomes a worker next period, while with probability $f(1-\sigma)$ a worker becomes a banker. Once the banker exits its business, retained earnings are transferred to the household and the bank shuts down. Any new banker obtains a startup fund, o_t, from the household. This setup ensures that financial intermediaries are unable to finance all investment projects with retained earnings and thus remain dependent on deposits. The representative household maximizes lifetime utility subject to a budget constraint. Letting c_t denote household consumption and h_t hours worked, the objective is given by

$$\max_{c_t, D_t^h, B_t^h, h_t} E_t \sum_{t=0}^{\infty} \beta^t e^{\eta_{d,t}} \left(\log(c_t - hc_{t-1}^a) - \chi_h \frac{h_t^{1+\varphi}}{1+\varphi} \right)$$

subject to

$$\begin{aligned} s.t.\ \ c_t + \frac{D_t^h}{P_t} + \frac{P_t^b B_t^h}{P_t} + \frac{1}{2}\kappa_b \left(\frac{P_t^b B_t^h}{P_t} - \bar{b}_h \right)^2 \leq & (1-\tau_t)\left(w_t h_t + d_t^{firms} \right) + \tau_t^{tr} + \\ & \underbrace{\frac{R_{t-1}^s}{\Pi_t}}_{R_t^d} \underbrace{\frac{D_{t-1}^h}{P_{t-1}}}_{d_{t-1}^h} + \underbrace{\frac{\left(1+\rho P_t^b\right)}{P_{t-1}^b} \frac{1}{\Pi_t}}_{R_t^b} \underbrace{\frac{P_{t-1}^b B_{t-1}^h}{P_{t-1}}}_{b_{t-1}^h} - o_t \end{aligned}$$

In the expression above E_0 is the expectation operator. Technological progress (defined below) is non-stationary, hence logarithmic utility ensure the existence of a balanced growth path. Additionally, there are (external) consumption habits and c_t^a denotes the average consumption in the economy. $\beta \in (0,1)$ is the discount factor, χ_h is a positive constant and $\eta_{d,t}$ a preference shock which follows an AR(1) process.

In the budget constraint d_t^h denotes real bank deposits and b_t^h holdings of real government debt, which is costly to the extent that it differs from a target level $\bar{b}_h$ (Gertler and Karadi, 2013).[6] κ_b is a positive constant. τ_t is the tax rate, w_t the real wage, d_t^{firms} are dividends which accrue to households who own the different firms (see below). τ_t^{tr} are transfers, R_t^d is the ex post real return on deposits, given by $R_{t-1}^s \Pi_t^{-1}$, where R_{t-1}^s is the nominal interest rate on deposits contracted in period $t-1$ and Π_t is inflation in period t. R_t^b is the (gross) real return on government bonds and will be defined in detail below. o_t are transfers to family members that start a new bank. Optimality for holding government bonds requires the following condition to hold

$$E_t \Lambda_{t,t+1} \left(R_{t+1}^b - R_{t+1}^d \right) = \kappa_b \left(b_t^h - \bar{b}^h \right), \tag{2.1}$$

where $\Lambda_{t,t+k} = \beta^k \frac{\lambda_{t+k}}{\lambda_t}$ denotes the household's stochastic discount factor and λ_t the Lagrange-Multiplier on the budget constraint.

2.2 Banks

A representative bank relies on deposits and retained earnings to fund either the capital stock of non-financial firms or purchases of government debt. Letting s_t denote the funding of non-financial firms by banks, b_t^b the stock of government debt held by the bank and n_t the banks equity position (or net worth), we can write the balance sheet of the bank as follows:

$$s_t + b_t^b = d_t^h + n_t.$$

Letting R_t^k (to be defined below) denote the real return of investing in non-financial firms, net worth evolves as follows:

$$\begin{aligned} n_{t+1} &= R_{t+1}^k s_t + R_{t+1}^b b_t^b - R_{t+1}^d d_t^h, \\ &= \left(R_{t+1}^k - R_{t+1}^d \right) s_t + \left(R_{t+1}^b - R_{t+1}^d \right) b_t^b + R_{t+1}^d n_t, \end{aligned} \tag{2.2}$$

where we use the bank's balance sheet to obtain the second equation.

The expected present discounted value of a bank's net worth at the time of exit from the banking business is given by

$$V_t = \sum_{k=1}^{\infty} (1-\sigma) \sigma^{k-1} E_t \Lambda_{t,t+k} n_{t+k}. \tag{2.3}$$

One important friction in the banking sector is an agency problem between intermediaries and depositors, because, as in Gertler and Karadi (2011, 2013), bankers may divert a fraction of assets. Specifically, we assume that this fraction is $\theta \in (0,1)$ for private-sector funding and $\Delta\theta$ for government debt, where $\Delta \in (0,1)$. The former is easier to divert, because its value is harder to observe by depositors. As a result, we require the following *incentive constraint* to be satisfied for depositors being willing to lend to the bank:

$$V_t \geq \theta s_t + \Delta \theta b_t^b. \tag{2.4}$$

Central to our analysis is the ability of the government to lower the yield on government

[6]This is meant to capture the limited participation of households in the market for government debt.

debt. To allow for this possibility we assume a *regulatory constraint*, as suggested by Chari, Dovis, and Kehoe (2016). Specifically, the following has to hold:

$$b_t^b \geq \Gamma_t \left(b_t^b + s_t\right).$$

Here Γ_t is the minimum share of government debt which banks need to hold relative to the total amount of assets. We think of this regulatory constraint as capturing a variety of measures such as those discussed by Reinhart and Sbrancia (2015) in some detail. Such measures may not literally force financial intermediaries to hold a certain fraction of government debt in their portfolio. Still they effectively raise the demand and thus price of government debt. As we show below, this is precisely the implication of constraint (2.5). We rearrange the regulatory constraint slightly

$$b_t^b \geq \gamma_t s_t, \tag{2.5}$$

with $\gamma_t = \frac{\Gamma_t}{1-\Gamma_t}$.

Maximizing (2.3) subject to (2.2), (2.4) and (2.5) yields the first order conditions:

$$E_t \tilde{\Lambda}_{t,t+1} \left(R_{t+1}^k - R_{t+1}^d\right) = \underbrace{\frac{\zeta_t}{1+\zeta_t}}_{\tilde{\zeta}_t} \theta + \underbrace{\frac{\mu_t}{1+\zeta_t}}_{\tilde{\mu}_t} \gamma_t = \tilde{\zeta}_t + \tilde{\mu}_t \gamma_t, \tag{2.6}$$

$$E_t \tilde{\Lambda}_{t,t+1} \left(R_{t+1}^b - R_{t+1}^d\right) = \Delta \tilde{\zeta}_t - \tilde{\mu}_t, \tag{2.7}$$

Here ζ_t and μ_t are the multipliers on the incentive and on the regulatory constraint, respectively. $\tilde{\Lambda}_{t,t+1}$, in turn, is an augmented stochastic discount factor defined below. Equation (2.6) relates the (expected) excess return of investing in intermediate-good firms (relative to the deposit rate) to the tightness of the incentive constraint (2.4) and regulatory constraint (2.5). Intuitively, to the extent that bankers are leverage constrained expected excess yields persist in equilibrium. Additionally, due to the distortion of the banks' portfolio choice through government regulation, a binding regulatory constraint (i.e. $\mu_t > 0$) reflects an artificially reduced demand for real capital, that results in a further elevated excess yield. This wedge rises, if the fraction of real capital that banks hold is low (i.e. a high value of γ_t)

Equation (2.7), in turn, relates the (expected) excess return of investing in government debt (relative to the deposit rate). Government debt is long-term, as we explain in detail below. Deposits, on the other hand, mature in the next period. Therefore, (2.7) relates the difference between long and short-term interest rates, to the tightness of the incentive constraint. Our model may thus rationalize a term premium due to market segmentation (see Fuerst, 2015). In our setup, there is market segmentation because households find it costly to adjust their debt holdings and banks are leverage constrained. As a result, there are limits to arbitrage and differences in expected yields persist in equilibrium. Yet, in addition to the excess-return component (or "term premium") reflected by $\Delta\tilde{\zeta}_t$, there is a "regulatory discount" which appears in equation (2.7) via μ_t. Recall that this is the multiplier on the regulatory constraint. The tighter the constraint (2.5), the lower the expected excess return on government debt. Intuitively, to the extent that regulatory constraint binds, the price of government debt is pushed up and (expected) yields are depressed because banks are incentivized to hold on to them. Note that the expected excess return on government debt given in (2.7) does not feature a liquidity premium, in line with the evidence.[7]

It is instructive to consider a version of the complementary slackness condition associated with the regulatory constraint (2.5)

$$E_t \left\{ \tilde{\Lambda}_{t,t+1} \left(R^b_{t+1} - \tilde{R}_{t+1} \right) \right\} \left(b^b_t - \gamma_t s_t \right) = 0. \tag{2.8}$$

Here $\tilde{R}_{t+1}$ is the laissez-faire interest rate which would obtain if the regulatory constraint were slack ($\mu_t = 0$). This expression shows that whenever there is financial repression, that is, whenever $R^b_{t+1} < \tilde{R}_{t+1}$, the regulatory constraint must bind. In our analysis below we assume that the regulatory constraint binds throughout. However, the extent of repression will vary over time. Either because of variations in γ_t or because, for a given γ_t, the tightness of the constraint, captured by μ_t, will generally differ across periods and states of the economy.

Following Gertler and Karadi (2013) we also assume that the incentive constraint binds always. It is then possible to the define the leverage ratio ϕ_t as follows:

$$s_t + b^b_t = \phi_t n_t, \tag{2.9}$$

where

$$\phi_t = \frac{E_t \tilde{\Lambda}_{t,t+1} R^d_{t+1}}{\theta + \theta \Delta \gamma_t - E_t \tilde{\Lambda}_{t,t+1} \left[\left(R^k_{t+1} - R^d_{t+1} \right) + \gamma_t \left(R^b_{t+1} - R^d_{t+1} \right) \right]}. \tag{2.10}$$

The leverage ratio falls in θ, the fraction of assets a banker can divert. Depositors anticipate that the incentive for the banker to divert assets increase and thus ask for more "skin in the game". The leverage ratio rises with the excess return on capital $E_t \tilde{\Lambda}_{t,t+1} \left(R^k_{t+1} - R^d_{t+1} \right)$ or bonds $E_t \tilde{\Lambda}_{t,t+1} \left(R^b_{t+1} - R^d_{t+1} \right)$, since that increases the value of staying a banker. Similarly, the leverage ratio rises with the discounted deposit rate $E_t \tilde{\Lambda}_{t,t+1} R^d_{t+1}$ as for given excess returns, the net worth of the bank and thus the value of staying a banker increases. We can now define the augmented discount factor as in Gertler and Karadi (2013):

$$\tilde{\Lambda}_{t,t+1} \equiv \Lambda_{t,t+1} \left(1 - \sigma + \sigma \frac{\partial V_{t+1}}{\partial n_{t+1}} \right), \tag{2.11}$$

with

$$\frac{\partial V_t}{\partial n_t} = E_t \tilde{\Lambda}_{t,t+1} \left[\left(R^k_{t+1} - R^d_{t+1} \right) \phi_t + \left(R^b_{t+1} - R^d_{t+1} \right) \gamma_t \phi_t + R^d_{t+1} \right]. \tag{2.12}$$

The augmented discount factor used to price the excess return is thus a probability-weighted average of the stochastic discount factor from the households and the marginal increase in net-worth of the bank. Since both constraints are always binding we arrive at

$$V_t = \theta s_t + \Delta \theta b^b_t \tag{2.13}$$

and

$$b^b_t = \gamma_t \left(b^b_t + s_t \right). \tag{2.14}$$

[7] Longstaff (2004) finds that liquidity premia on short-term and long-term treasuries are of similar magnitude. In our model as well as in our empirical analysis below we do not distinguish between the return on short-term deposits and the return on short-term government debt.

The aggregate stock of net worth n_t depends on the returns of bankers that stay a banker (probability σ) and the start-up funds for new bankers:

$$n_t = \sigma \left[\left(R_t^k - R_t^d \right) s_{t-1} + \left(R_t^b - R_t^d \right) b_{t-1}^b + R_t^d n_{t-1} \right] + o_t. \tag{2.15}$$

2.3 Firms

We distinguish between four types of firms. There are intermediate good firms which operate under perfect competition. They hire workers from the employment agencies and use the capital stock which is funded by banks. Next there a monopolistically competitive retailers which are constrained in their price-setting decision. Last, there are capital producers and the employment agencies.

2.3.1 Intermediate good firms

The representative intermediate good firm operates under perfect competition. Its production function is given by

$$y_t = \left(u_t k_{t-1} \right)^{\alpha} \left(Z_t h_t(j) \right)^{1-\alpha}, \quad \alpha \in (0,1).$$

Here, production depends on the predetermined capital stock k_{t-1} and its utilization u_t. Z_t represents exogenous labor-augmenting technological progress. We allow it be non-stationary and assume that its growth rate, $\eta_{z,t} \equiv \Delta \log Z_t$, follows an AR(1) process (Justiniano, Primiceri, and Tambalotti, 2013).

As price taker, the firm's demand for labor and capital utilization satisfies the optimality conditions

$$w_t = p_t^m (1-\alpha) \frac{y_t}{h_t} \tag{2.16}$$

and

$$\alpha p_t^m \frac{y_t}{u_t} = \Psi'(u_t) k_{t-1}. \tag{2.17}$$

Here p_t^m denotes the real price of intermediate goods and $\Psi(u_t) = (1+\kappa)^{-1}(u_t^{1+\kappa} - 1)$ is the cost of capital utilization. We assume that in steady state $u = 1, \Psi(1) = 0$ and define $\kappa \equiv \frac{\Psi''(1)}{\Psi'(1)}$. After production takes place the intermediate goods producer buys new capital goods of x_t at price q_t. Letting δ the rate of depreciation, the the law of motion of the capital stock is given by

$$k_t = (1-\delta) k_{t-1} + x_t. \tag{2.18}$$

The capital stock is fully funded through banks. We follow Jermann (1998) and Basu and Bundick (2017) in assuming that a constant fraction ν of the capital stock is financed through bank loans, that is $l_t = \nu q_t k_t$ and the rest by equity shares, $e_t = (1-\nu) q_t k_t$ (also held by banks).[8] It thus holds

$$s_t = e_t + l_t = q_t k_t. \tag{2.19}$$

As a result, intermediate good firms are leveraged and banks' returns from holding equity in intermediate good firms may be as volatile as in the data. In contrast to banks, firms' leverage

[8] We normalize the amount of shares to 1 such that e_t is the price of total shares.

has no real implications due to perfect monitoring. Therefore, the firm obtains loans at the prevailing real deposit rate R_t^d.

The firm does not keep any retained earnings. Dividend payments thus amount to $d_t^f = p_t^m y_t - w_t h_t - \Psi(u_t) k_{t-1} - q_t x_t - \left(R_t^d l_{t-1} - l_t\right)$. The return on equity reflects price changes as well as dividends and is given by:

$$R_t^e = \frac{e_t + d_t^f}{e_{t-1}} = \frac{\Psi'(u_t) u_t - R_t^d \nu q_{t-1} - \Psi(u_t) + (1-\delta) q_t}{(1-\nu) q_{t-1}}, \tag{2.20}$$

where the first order condition (2.17) has been substituted in. From the perspective of the bank, however, the total return on funding the capital stock is key, that is, we have to add the gross return on its loan-payments less the new loan given to the firm:

$$R_t^k = \frac{e_t + d_t^f + \left(R_t^d l_{t-1} - l_t\right)}{e_{t-1}} = \frac{\Psi'(u_t) u_t - \Psi(u_t) + (1-\delta) q_t}{q_{t-1}}. \tag{2.21}$$

2.3.2 Retailers

There is a continuum of monopolistically competitive retailers $j \in [0,1]$ which repackage and diversify intermediate goods. Retailers transform one unit of intermediated goods into one unit of the retail good such that marginal costs are given by p_t^m.

Final goods consist of products of all retailers:

$$y_t = \left[\int_0^1 y_t(j)^{\frac{1}{1+\omega_{p,t}}} dj\right]^{1+\omega_{p,t}}.$$

Here $\omega_{p,t}$ varies exogenously. Cost minimization implies that the demand for goods of a generic retailer j is given by

$$y_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\frac{1+\omega_{p,t}}{\omega_{p,t}}} y_t, \tag{2.22}$$

where $P_t(j)$ is the price charged by retailer j and P_t is the price index of the final good given by

$$P_t = \left[\int_0^1 P_t(j)^{-\frac{1}{\omega_{p,t}}}\right]^{-\omega_{p,t}}. \tag{2.23}$$

$\omega_{p,t}$ denotes the desired markup of prices over the marginal costs. We assume that $\log(1+\omega_{w,t})$ follows an AR(1) process. We follow Rotemberg (1982) and assume that the adjustment of priced entails some quadratic costs for the retail firm:

$$ac_t(j) = \frac{1}{2}\varphi\left[\frac{P_t(j)}{P_{t-1}(j)} - \Pi_{t-1}^{\xi}\Pi^{1-\xi}\right]^2 y_t(j) p_t(j),$$

with φ determining the cost of price adjustments, Π is the steady state inflation rate, $\xi \in (0,1)$ captures price indexation and $p_t(j) = \frac{P_t(j)}{P_t}$ is the price in real terms.

Retailers set prices $P_t(j)$ in order to maximize discounted life-time profits:

$$\max_{P_t(j)} E_t \sum_{k=0}^{\infty} \underbrace{\Lambda_{t,t+k}(1-\tau_{t+k})}_{\Lambda_{t,t+k}^{\tau}} \left\{\left(p_{t+k}(j) - p_{t+k}^m\right) y_{t+k}(j) - ac_{t+k}(j)\right\},$$

subject to the demand function (2.22).

Optimality requires the following condition to be satisfied

$$-\frac{1}{\omega_{p,t}}+p_t^m\frac{1+\omega_{p,t}}{\omega_{p,t}}-\varphi\left(\Pi_t-\Pi_{t-1}^{\xi}\Pi^{1-\xi}\right)\Pi_t+\frac{1+\omega_{p,t}}{\omega_{p,t}}\frac{\varphi}{2}\left(\Pi_t-\Pi_{t-1}^{\xi}\Pi^{1-\xi}\right)^2+ \\ \frac{\Lambda_{t,t+1}^{\tau}}{\Lambda_{t,t}^{\tau}}\varphi\left(\Pi_{t+1}-\Pi_t^{\xi}\Pi^{1-\xi}\right)\Pi_{t+1}\frac{y_{t+1}}{y_t}=0. \tag{2.24}$$

2.3.3 Capital producers

Capital producers use final goods to produce capital goods subject to an adjustment cost. They sell capital goods to intermediate good firms and distribute profits to the household sector. The objective of capital produces is given by

$$\max_{x_t}\sum_{k=0}^{\infty}\Lambda_{t,t+k}\left\{q_{t+k}x_{t+k}-e^{-\eta_{x,t+k}}\left[1+\Theta\left[\frac{x_{t+k}}{x_{t+k-1}}\right]\right]x_{t+k}\right\}$$

Where $\eta_{x,t}$ is an investment specific shock which we specify as an AR(1), $\Theta\left[\frac{x_t}{x_{t-1}}\right]=\frac{\varkappa}{2}\left(\frac{x_t}{x_{t-1}}-e^{\gamma}\right)^2$ is the adjustment cost function with $\varkappa>0$ and γ is the steady state growth rate of neutral technology. The associated first order condition is given by

$$q_t=e^{-\eta_{x,t}}\left(\left(1+\Theta\left[\frac{x_t}{x_{t-1}}\right]\right)+\Theta'\left[\frac{x_t}{x_{t-1}}\right]\frac{x_t}{x_{t-1}}\right)-\Lambda_{t,t+1}e^{-\eta_{x,t+1}}\left(\Theta'\left[\frac{x_{t+1}}{x_t}\right]\frac{x_{t+1}^2}{x_t^2}\right).$$

If there are no adjustment costs, i.e. $\Theta[\cdot]=\Theta'[\cdot]=0$, then $q_t=\frac{1}{e^{\eta_{x,t}}}$, that is, marginal Tobin's Q is equal to the replacement cost of capital (the relative price of capital).

2.3.4 Employment agencies

We follow Justiniano, Primiceri, and Tambalotti (2013) and Erceg, Henderson, and Levin (2000) and assume that each household is a monopolistic supplier of a differentiated labor service which it sells to an employment agency. A unit mass of these agencies aggregates the specialized types into a homogenous labor input and sells to intermediate good firms:

$$h_t=\left[\int_0^1 h_t(j)^{\frac{1}{1+\omega_{w,t}}}\right]^{1+\omega_{w,t}}. \tag{2.25}$$

Here $\omega_{w,t}$ denotes the desired markup of wages over the households' marginal rate of substitution between labor and leisure. We assume that $\log(1+\omega_{w,t})$ follows an AR(1) process. Employment agencies maximize profits such that labor demand is given by

$$h_t(j)=\left(\frac{w_t(j)}{w_t}\right)^{-\frac{1+\omega_{w,t}}{\omega_{w,t}}}h_t. \tag{2.26}$$

Here $w_t(j)$ denotes the real wage paid to households j and w_t is the aggregate wage index given by

$$w_t=\left[\int_0^1 w_t(j)^{-\frac{1}{\omega_{w,t}}}\right]^{-\omega_{w,t}}. \tag{2.27}$$

We further assume that each period only a constant fraction $1-\theta^w$ of housholds/labor types can optimally adjust their nominal wages, the rest follows the simple index rule

$$w_t(j) = w_{t-1}(j) \left(\Pi_{t-1} e^{\eta_{z,t}}\right)^{\xi^w} \left(\Pi_{t-1} e^{\gamma}\right)^{1-\xi^w}. \tag{2.28}$$

2.4 Government

In each period the government finances purchases, transfers and interest rate payments by raising taxes and issuing nominal debt which is default free. The maturity of government may exceed one period. Specifically, as in Woodford (2001), we assume that one unit of government debt B_t issued in period t offers the following payment stream: $\{1, \rho, \rho^2, \rho^3, \ldots\}$. Here, the decay factor ρ captures the average maturity of the bond. Letting p_t^l denote the real price for this bond, the market value of debt in real terms is given by $b_t = p_t^l B_t$. In the absence of arbitrage across different maturities and given p_t^l, the real price of a bond in period $t+k$ must be given by $\rho^k p_t^l$. The ex post yield of holding long-term government debt in real terms is given by

$$R_t^b = \frac{\frac{1}{P_t} + \rho p_t^l}{p_{t-1}^l}. \tag{2.29}$$

We write the budget constraint using variables measured relative to GDP. Specifically, R_t^b denotes the ex-post real interest rate of government debt, $d_t \equiv b_t/y_t$ the debt-to-GDP ratio, y_t real output, e_t the expenditure ratio (sum of purchases and transfers) and τ_t^{total} total tax revenues:

$$R_t^b d_{t-1} \frac{y_{t-1}}{y_t} + e_t = d_t + \tau_t^{total}. \tag{2.30}$$

We follow the setup by Bianchi and Ilut (2016) for expenditures and purchases. Specifically, we decompose total expenditures into a short-term component e_t^s and a long-term component e_t^l. The long-term component follows a highly persistent AR(1) process which is meant to capture the large and long-lasting transfer programs (Great Society), while the short-term component will react on current output to capture transfer adjustments over the business cycle. We use a hat to denote the percentage deviation of a variable from its steady state, and a tilde to denote a percentage point deviation. The process for short-term expenditures is given by:

$$\tilde{e}_t^s = \rho_e^s \tilde{e}_{t-1}^s + (1-\rho_e^s)\, \phi_y \hat{y}_t + \varepsilon_t^{e,s}. \tag{2.31}$$

Government purchases g_t are given by $g_t = \left(1 - \frac{1}{\varrho_t}\right) y_t$, where ϱ_t is an AR(1) government spending shock. The purchases to expenditure ratio ϱ_t evolves according to

$$\tilde{\varrho}_t = \rho_\varrho \tilde{\varrho}_{t-1} + (1-\rho_\varrho)\, \phi_y^\varrho \hat{y}_t + \varepsilon_t^\varrho \tag{2.32}$$

which is smooth but additionally allows for a contemporanous feedback effect of output to transfers (ϕ_y^ζ).

The total amount of tax revenues is given by $\tau_t^{total} = \tau_t \left(w_t h_t + d_t^{firms}\right)$. We assume that the tax rate adjusts according to the following rule:

$$\tilde{\tau}_t = \rho_\tau \tilde{\tau}_{t-1} + (1-\rho_\tau) \left(\phi_d \tilde{d}_t + \phi_y^\tau \hat{y}_t\right) + \eta_{\tau,t}, \tag{2.33}$$

with iid stochastic disturbance $\eta_{\tau,t}$.

Finally, monetary policy sets the nominal short-term interest rate by following an interest rate rule

$$\frac{R_t^s}{R^s} = \Big(\frac{R_{t-1}^s}{R^s}\Big)^{\rho_r} \Big(\Big(\frac{\Pi_t}{\tilde{\Pi}}\Big)^{\phi_\pi}\Big)^{1-\rho_r} e^{\eta_{r,t}} \tag{2.34}$$

where ρ_r a smoothing parameter, ϕ_π and ϕ_y capture the reaction coefficients to inflation and output respectively and $\eta_{r,t}$ is an iid monetary policy shock.

2.5 Market clearing

At the aggregate level, the following resource constraint needs to be satisfied

$$y_t = c_t + g_t + e^{-\eta_{x,t}}\left[1 + \Theta\left[\frac{x_t}{x_{t-1}}\right]\right] x_t + \frac{1}{2}\varphi\left[\Pi_t - \Pi_{t-1}^{\xi}\Pi^{1-\xi}\right]^2 y_t + \Psi(u_t)k_{t-1}. \tag{2.35}$$

Since households and banking sector are investing in government debt the total stock, and thus the real market value, is the sum of both

$$b_t = b_t^b + b_t^h. \tag{2.36}$$

2.6 Inspecting the mechanism

In what follows we develop some intuition for how financial repression impacts public finances in particular and the economy in general. In a first step, we take a partial equilibrium perspective and zoom in on the market for government debt. Our discussion assumes that debt is held exclusively by banks: $B_t^b = B_t$. Further, we abstract from inflation and assume a constant fiscal surplus $s_t = s$. We then consider a simplified version of the government budget constraint:

$$P_t^b B_t = \frac{1 + \rho P_t^b}{P_{t-1}^b} P_{t-1}^b B_{t-1} - s.$$

This expression implicitly defines the supply curve of government debt: it relates the current price of debt P_t^b to the quantity of bonds B_t, given outstanding liabilities and bond prices in the previous period. The supply curve is downward sloping because a higher bond price reduces the amount of debt which needs to be placed with banks in order to redeem a given amount of outstanding debt net of the surplus. We depict the supply curve as the blue solid in Figure 2. It is labeled “S”.

The same figure also features a demand curve for government debt, labeled “D”, that determines the demand for government debt in the absence of repression or, equivalently, in case the regulatory constraint is not binding. Without loss of generality we assume it to be horizontal. As $R_t^b = \frac{1+\rho P_t^b}{P_{t-1}^b}$, it is implicitly determined by the bankers’ optimality condition (2.7) that ties the return on government debt to the deposit rate. The deposit rate, in turn, is proportional to the time-discount factor thanks to optimality condition (2.1). The intersection of “D” and “S” in Figure 2 determines the “laissez-faire” price $\tilde{P}^b$ of debt that prevails in the absence of repression.

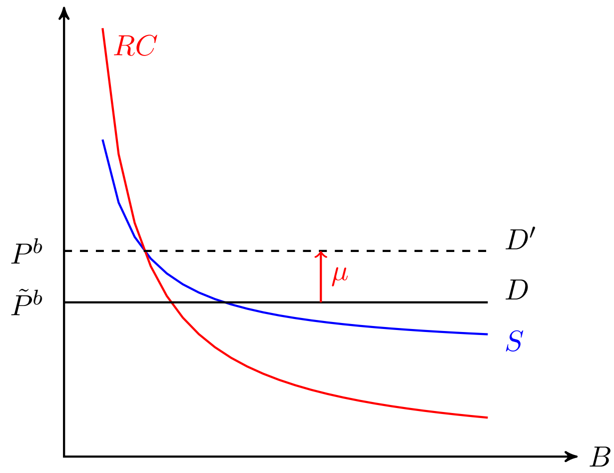

Figure 2: Stylized representation of market for government debt. Supply (demand) of debt represented by blue (black) line. Regulatory constraint represented by RC curve. $\tilde{P}^b$ is the laissez-faire price of debt. P^b is the actual price. Repression shifts demand for government debt upward.

Because $b_t = P_t^b B_t$, the regulatory constraint (2.5) implies

$$P_t^b B_t \geq \gamma_t s_t.$$

For a given market value of firms, s_t, the regulatory constraint defines a downward sloping relationship between the price of debt and the amount of debt that needs to be held by banks whenever the regulatory constraint binds. It is shown as a hyperbola in Figure 2, depicted in red and labeled RC. Intuitively, the constraint is satisfied with equality if either the volume held by banks is high and the price is low, or vice versa.

What determines the equilibrium in the market for government debt? Since we assume that the regulatory constraint binds, the equilibrium price P^b is given by the intersection of RC and S. It exceeds the laissez-faire price. This price is consistent with the demand curve, because in case of repression the demand curve for government debt shifts upward (from D to D'). Formally, this is brought about by a positive realization of the Lagrange multiplier μ in the bankers' optimality condition (2.7). Because holding an additional unit of government debt provides additional value to the bank if the regulatory constraint binds, bankers are ready to purchase government debt at a price which exceeds the laissez-faire price. Equivalently, for a given price of government debt in the next period, repression lowers the yield on government debt. At the same time, due to repression the government needs to issue less debt in order to meet a given financing requirement.

How does the economy adjust to financial repression? In order to illustrate essential aspects of the transmission mechanism we simulate a simplified version of the model outlined in Section 2.[9]

[9] Specifically, we assume that debt is held exclusively by banks, there is no habit persistence, wages are set in a perfectly competitive way, there are no government expenditures (purchases or transfers), monetary and fiscal rules have no smoothing terms, monetary policy adjusts interest rates only in response to inflation and there are taxes are lump-sum. We also assume that monetary policy is active and fiscal policy is passive, following the notation by Leeper (1991). Results are qualitatively similar for the estimated model as we show below.

Specifically, we assume that the economy is initially in steady state as the regulatory constraint tightens temporarily. There is in other words a shock to γ_t. We contrast the effects of this repression shock with those of a conventional monetary policy shock, that is, an exogenous reduction of the short-term policy rate.

Figure 3 shows the impulse response functions. The blue solid line is the response to the repression shock. The red dashed line is the response to the (expansionary) monetary policy shock. Here vertical axes indicate deviations from steady state and horizontal axes indicate time in quarters. Focus first on the repression shock. The upper panel of figure 3 shows the implications for public finances and inflation. Increased financial repression—via the regulatory constraint—requires banks to hold a higher fraction of their portfolio in government debt. All else equal they increase their demand for debt which in turn raises its price (not shown) and lowers the expected return (upper right graph). The reduction of the interest rate, all else equal, reduces the debt-to-GDP ratio (lower middle graph). However, initially public debt increases because repression raises the price of outstanding debt, and thus the holding period return HPR (lower left graph). Furthermore the reduction in inflation increases the real market value of debt. Therefore, the net effect of a repression shock on the debt ratio is ambiguous and likely to change over time.

The lower panel of Figure 3 shows how the repression shock transmits into the economy. As the regularity constraint tightens, banks respond by rebalancing their portfolios: they reduce their funding of firms as they are forced to hold more government debt. As a result, the price of investment (Tobins Q) declines (upper left graph) as does investment (lower left graph). As stressed by Chari, Dovis, and Kehoe (2016), repression distorts the optimal allocation of capital. Repression crowds out investment via this *portfolio effect*. In addition, there is a *net worth effect*: since the value of investment and the return on government decline, banks net worth declines (upper middle graph).[10] This kicks off a second round effect. First, since banks' equity is directly linked to real lending (due to market segmentation), investment drops even further which drives the economy into a prolonged recession (lower right graph). Second, since net equity is reduced, households withdraw their deposits from the banks, as the value of staying a banker falls and households only have limited enforcement capabilities. This additionally reduces lending and thus enhances the drop in investment and output. Even though the increase in repression dies out after 20 quarters, output is still below its steady-state value (lower right graph). This, in turn, may put upward pressure on the debt-to-GDP ratio, as we discuss below.

At times, some commentators also refer to low policy rates as "financial repression". In our model, financial repression shares some features with conventional monetary policy, but is fundamental different in other dimensions. To illustrate this, the red dashed line in Figure 3 shows the responses to a cut in the interest rate. Focus on the upper panel first: we consider a cut in the policy rate which induces a decline of ex ante interest rates comparable to the one observed in response to the repression shock (upper right graph). The ex ante interest rate declines because prices are sticky and hence expected inflation (lower right graph) does not fully offset the change in the policy rate. The long-term rate declines with the short-term rate thanks

[10]This is despite the increase of the HPR on government debt in the first period, as it is more than offset by the loss in market value of the investment into real firms.

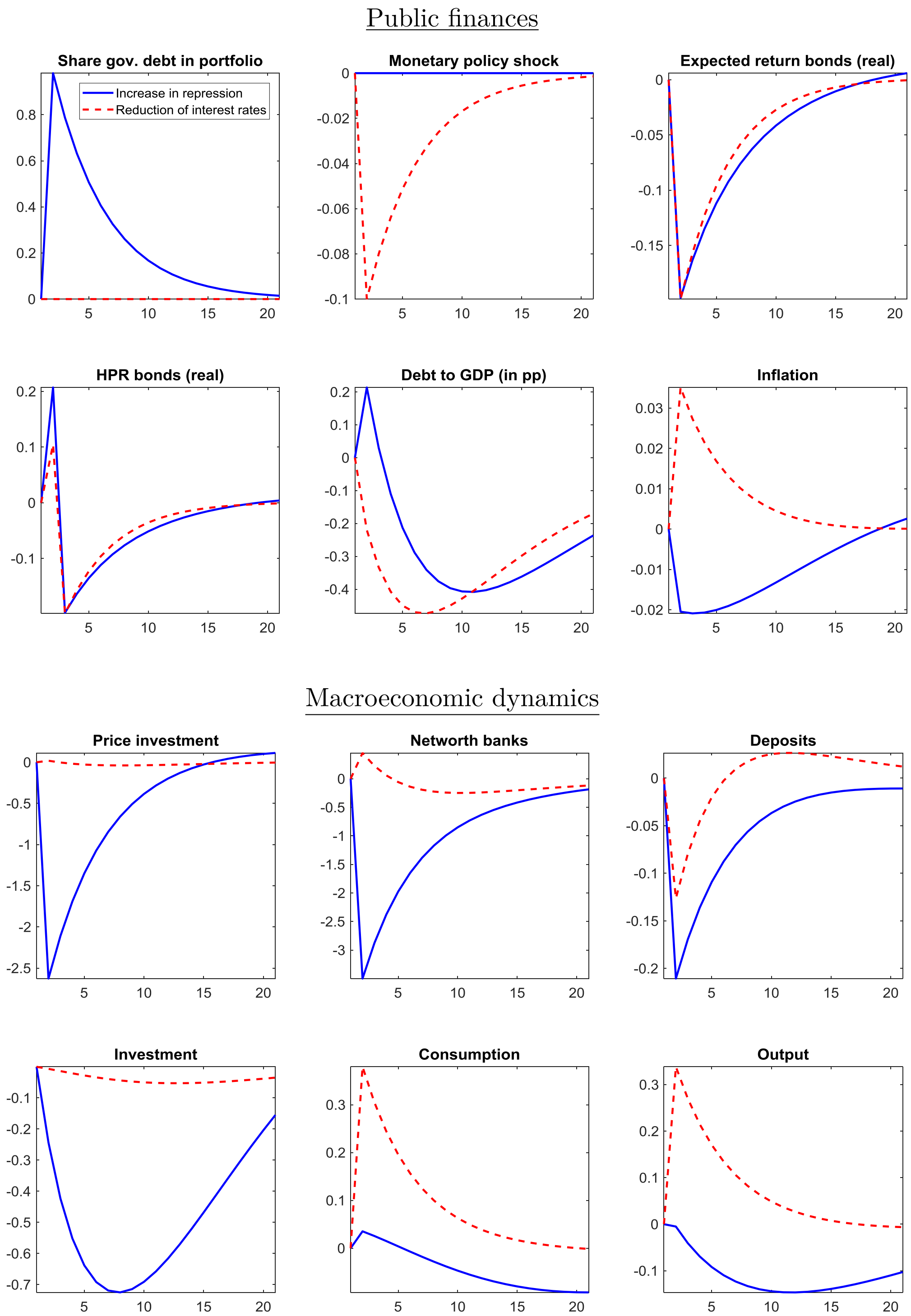

Figure 3: Dynamic effects of repression vs conventional monetary policy. Responses to repression shock (blue solid line) vs cut of policy rate (red dotted line). Vertical axis measures deviations from steady state, horizontal axis measures time in quarters.

to no-arbitrage conditions. Also, the holding period return on government debt evolves similar to what happens in response to repression (lower left graph). The public-debt-to-output ratio (lower middle panel) declines more strongly in response to the monetary policy shock, because the cut in the policy rate is expansionary. Yet, in sum, as far as public finances are concerned, the effects of the monetary shock are comparable to the repression shock.

There are stark differences when it comes to the transmission into the economy, shown in the lower panel of Figure 3. The reduction of interest rates stimulates household consumption (lower middle graph). In the process, households reduce their savings with banks (upper right graph). To meet the regulatory constraint banks have to reduce their funding of firms, as the increase in net worth (upper middle graph) is more than compensated by the fall in deposits. As a result investment declines somewhat (lower left graph).[11] However, the economy expands due to increased consumption. In contrast to the repression shock, the effect of the monetary policy shock on output is less persistent than in case of the repression shock because bankers' net worth is much less affected.

3 Estimation

We estimate the model using Bayesian estimation techniques. In this section, we first describe the dataset used to estimate the parameters of model. Afterwards, we outline the choice of the prior distribution of the parameters and report the corresponding posterior distributions.

3.1 Data

We estimate the model using ten time series of US quarterly data from 1948Q2–1974Q4. Four of these series are macro time series, four are fiscal time series and two time series capture the financial sector.

We obtain real per capita GDP growth from NIPA (nominal GDP: Table 1.1.5, line 1 and GDP deflator: Table 1.1.4, line 1). We follow Leeper, Plante, and Traum, 2010 in constructing the population series. Furthermore, we use the real per capita growth rate of private investment, which is the sum of personal consumption expenditures on durable goods (Table 1.1.5, line 4) and gross private domestic investment (Table 1.1.5, line 7). Additionally, we include the inflation rate, measured as the quarterly log difference of the GDP deflator. Since the Federal Reserve started targeting a specific rate only from June 1954, we use as measures for the nominal interest rate the secondary market rate of the 3m Treasury Bill until 1954Q2 and thereafter by the effective Federal Funds rate.[12]

As fiscal time series we include the market value of debt relative to GDP[13]government purchases, government expenditures and government revenues. We obtain the market value of debt from Cox and Hirschhorn (1983), data for government purchases, expenditures and

[11]Since the liability side shrinks, so does the asset side. Financial repression is still present in steady state, however, therefore the relative share of public debt and funding of firms has to be kept similar. The reduction in liabilities is thus met by a reduction of investment and government debt (not shown) of a similar size.

[12]Both rates are not completely identical but follow a very close pattern as demonstrated by a correlation coefficient of 0.98 for 1954Q3 to 1974Q4.

[13]We use the market value of privately held government debt. Since we assume a consolidated budget we abstract from debt held by the Federal Reserve or U.S. government accounts.

revenues from NIPA. We transform government purchases to be consistent with ϱ_t in the model and define government expenditures as the sum of purchases and transfers, all relative to GDP.[14] We compute tax revenues as the difference between current receipts (NIPA Table 3.2, line 37) and current transfer receipts (NIPA Table 3.2, line 16).

As financial frictions are at the heart of our analysis, we also use two financial time series in the estimation: bank equity and equity returns.[15]

$$\begin{bmatrix} \text{dlGDP}_t \\ \text{dlInvestment}_t \\ \text{dlGDPDeflator}_t \\ \text{dlInterestRate}_t \\ \text{GovDebtRatio}_t \\ \text{ExpenditureRatio}_t \\ \text{TaxRatio}_t \\ \text{Purchases}_t \\ \text{dlBankEquity}_t \\ \text{dlReturnOnEquity}_t \end{bmatrix} = 100 \cdot \begin{bmatrix} a \\ a \\ \log(\Pi) \\ \log(e^a \Pi/\beta) \\ d \\ e \\ \tau \\ \log(\varrho) \\ a \\ \log(R^e) \end{bmatrix} + \begin{bmatrix} \hat{y}_t - \hat{y}_{t-1} + \tilde{\eta}_t^z \\ \hat{x}_t - \hat{x}_{t-1} + \tilde{\eta}_t^z \\ \hat{\pi}_t \\ \hat{r}_t \\ \tilde{d}_t \\ \tilde{\eta}_t^e \\ \tilde{\tau}_t \\ \hat{\varrho}_t \\ \hat{n}_t - \hat{n}_{t-1} + \tilde{\eta}_t^z \\ \hat{R}_t^e \end{bmatrix},$$

where dl is 100 times the log difference of each variable while the rest is the observed ratio. Remember that a hat (ˆ) denotes the log-deviation and tilde (˜) the linear deviation from steady state. Note that in the model most variables inherit the non-stationarity of the technological progress Z_t. We therefore express variables in deviations from the non-stationary trend (a). Then, we (log-)linearize the model around its non-stochastic steady state.

The estimation sample starts in 1948Q2 because the population series only goes back until 1948. It ends in 1974Q4 for two reasons: First, in 1974 the federal debt to GDP ratio is the lowest after WWII and thus this period is characterized by a large reduction in the debt to GDP ratio from 75.5% to 16.9%. Second, the period afterwards, especially after the appointment of Volcker 1979 marks a shift in the conduct of monetary policy, see for example Clarida, Gali, and Gertler (2000) or Bianchi and Ilut (2016).

3.2 Choice of prior distribution

Most of the parameters have been estimated before and we therefore follow the choices of the corresponding literature, e.g. Justiniano, Primiceri, and Tambalotti (2013) and Bianchi and Ilut (2016). As for the banking sector we follow the suggestions by Gertler and Karadi (2013). The left panel of Table 1 summarizes the the prior distribution of the model parameters.

The first block contains parameters which characterize the behavior of policy, starting with

[14]Data for purchases are from NIPA tables Table 3.2, line 21 (consumption) Table 3.2, line 41 (investment) and Table 3.2, line 43 (net purchases of non-produced assets) minus Table 3.2, line 44 (consumption of fixed capital). Transfers are given by the sum of net current transfer payments (Table 3.2, line 22 and line 16), subsidies (Table 3.2, line 32), and net capital transfers (Table 3.2, line 42 and line 38).

[15]We retrieve bank equity from the Board of Governors of the Federal Reserve System. Specifically, we use total capital accounts for all commercial banks from H.8. - Assets and Liabilities of Commercial Banks in the U.S., transform it into real per capita values as explained below and take the growth rates as observable. We always use the last available entry for each quarter. To compute equity returns we use the mean quarterly price and dividend data on the US stock market provided by Shiller (2005), deflate it and calculate the return on equity including the dividend payments.

Table 1: Prior and posterior distribution of estimated parameters

		Prior			Posterior			
		Dist	Mean	SE	Mode	Mean	5 percent	95 percent
Γ	Regulation	N	0.30	0.05	0.2672	0.2693	0.2068	0.3331
ϕ_π	MP on inflation	N	1.00	0.50	0.4912	0.4834	0.4025	0.5678
τ_d	Tax on debt	N	0	0.05	0.0569	0.0500	0.0201	0.0778
τ_y	Tax on output	N	0.20	0.20	0.5717	0.5235	0.3097	0.7183
ϕ_y	MP on output	G	0.25	0.10	0.1665	0.1585	0.0711	0.2439
ι_y	Exp share on output	N	0.10	0.20	0.0805	0.0708	-0.2614	0.3876
ϕ_y^{es}	SR-exp on output	N	0.20	0.40	-0.5897	-0.5984	-0.7358	-0.4518
100μ	Repression discount	G	0.50	0.20	0.5328	0.6247	0.2435	0.9930
$\tilde{\zeta}$	Term Premium	N	1.00	0.25	1.3440	1.3473	1.0710	1.6275
ϕ	Leverage ratio	N	6.00	1.00	7.3049	7.0104	5.6399	8.3585
σ	Survival rate banker	N	0.50	0.25	0.0055	0.0081	0.0003	0.0150
ν	Loan share	N	0.50	0.25	0.6121	0.6106	0.5575	0.6660
σ_{n_t}	ME networth	IG	0.50	0.05	0.6746	0.6763	0.5741	0.7754
ξ^π	Price indexation	B	0.50	0.15	0.4218	0.4125	0.2624	0.5622
ξ^w	Wage indexation	B	0.50	0.15	0.4638	0.4644	0.2153	0.7012
κ^π	NKPC-slope	G	0.30	0.15	0.0010	0.0011	0.0006	0.0017
θ^w	Wage adjustment	B	0.66	0.10	0.9224	0.9022	0.8604	0.9463
φ	Frisch elasticity	G	2.00	0.25	1.9964	2.0253	1.6174	2.4464
$\varkappa$	Inv. adjustment	G	4.00	1.00	2.3691	2.3757	1.8494	2.8583
κ	Utilization cost	G	5.00	1.00	5.0375	5.2346	3.5656	6.9161
100π	Inflation	N	0.75	0.05	0.7548	0.7533	0.6707	0.8337
100γ	Growth	N	0.59	0.05	0.5258	0.5278	0.4576	0.6011
d	Debt to GDP	N	1.49	0.10	1.6533	1.6526	1.4971	1.8071
ϱ	Purchases	N	1.12	0.01	1.1113	1.1122	1.0998	1.1243
τ	Tax revenue	N	0.17	0.01	0.1631	0.1634	0.1515	0.1754
AR(1) shocks								
ρ_Γ	Regulation	B	0.60	0.20	0.9962	0.9951	0.9913	0.9991
ρ_i	MP	B	0.60	0.20	0.9785	0.9730	0.9542	0.9922
ρ_τ	Tax rate	B	0.60	0.20	0.5112	0.5603	0.3728	0.7452
ρ_x	Investment	B	0.60	0.20	0.8714	0.8650	0.8069	0.9254
ρ_ϱ	Purchase/Exp.	B	0.60	0.20	0.9806	0.9773	0.9598	0.9954
ρ_z	Tfp	B	0.20	0.05	0.2106	0.2142	0.1303	0.3014
ρ_d	Demand	B	0.60	0.20	0.8121	0.7738	0.6585	0.8913
ρ_{e^s}	Short exp.	B	0.20	0.05	0.1414	0.1484	0.0859	0.2071
ρ_{μ^π}	Price markup	B	0.60	0.20	0.1107	0.1440	0.0314	0.2484
ρ_w	Wage markup	B	0.60	0.20	0.4968	0.4688	0.3009	0.6448
Std shocks								
σ_Γ	Regulation	IG	1.00	1.00	1.0516	1.0855	0.9164	1.2517
σ_i	MP	IG	0.50	0.50	0.1694	0.1726	0.1528	0.1924
σ_τ	Tax rate	IG	2.00	2.00	0.5730	0.6195	0.5039	0.7365
σ_x	Investment	IG	10.00	2.00	5.3883	5.5231	4.7167	6.2626
σ_ϱ	Purchase/Exp.	IG	1.00	1.00	3.6991	3.7351	3.2023	4.2611
σ_z	Tfp	IG	1.00	1.00	0.6141	0.6128	0.4712	0.7591
σ_d	Demand	IG	10.00	2.00	9.7390	9.6738	7.9758	11.3357
σ_{e^s}	Short exp.	IG	2.00	2.00	0.4837	0.5011	0.3981	0.6000
σ_μ	Price markup	IG	1.00	1.00	0.3400	0.3457	0.2913	0.3980
σ_w	Wage markup	IG	2.00	2.00	1.0890	1.3444	0.6852	2.0361

the amount of regulation in steady state, γ. For the prior mean (and the external validation of the time series below) we use the available date from H.8 above and calculate the share of government debt relativ to investment for the commercial banks.[16] The sample mean is a little above 0.3 and a standard deviation of 0.05, hence the values for the prior beta distribution. We allow in our analysis for different regimes of monetary and fiscal interaction. In particular, we will concentrate on uniquely determined bounded rational expectation equilibria. These regimes exhibit either an active monetary authority coupled with an passive fiscal authority (regime M) or a passive monetary authority coupled with an active fiscal authority (regime F). Regarding the parameters in the policy function we set a prior distribution such that both regimes can potentially prevail. The prior distribution of the monetary reaction coefficient on inflation, ϕ_π, is a normal distribution centered around 1 with a standard deviation of 0.5 and on output, ϕ_y, a gamma distribution with mean 0.25 and standard deviation of 0.1. The prior distribution of the coefficient on debt in the tax rule, τ_d, is a normal distribution with mean 0 and a standard deviation of 0.05 and on output, τ_y, is a normal distribution with mean 0.2 and a standard deviation of 0.2. The response coefficient of government spending and the coefficient determining the response of short-run expenditures to the output gap are assumed to have a normal distribution with mean 0.1 and 0.2 respectively.

The next block deals with parameters for the banking sector. The amount of repression discount μ in steady state has a gamma distribution with mean 0.5 and standard deviation of 0.2. The mean was chosen in line with Reinhart and Sbrancia (2015) who find that repression is around 2% annually for the United States. We use a normal distribution for the the term premium, $\tilde{\zeta}$, and the steady state leverage ratio ϕ with mean 1 and 6 and standard deviations of 0.25 and 1 respectively. We choose a beta distribution with mean 0.5 and standard deviation of 0.25 for the probability of staying a banker, σ and the amount of bonds that is financed by loans, ν. We include a measurement error in the series of networth with an inverse gamma centered tightly at 0.5. We follow Gertler and Karadi (2013) and calibrate κ_b to 1, since the data was not informative about its value.[17]

The indexation parameter for wage as well as price indexation follow a beta distribution with mean 0.5 and a standard deviation of 0.15. For the slope coefficient in the Phillips curve we specify a Gamma distribution with a mean of 0.3 and standard distribution 0.15. For the parameter controlling the wage stickiness we formulate a beta distribution with mean 0.66 and standard deviation 0.1. For the inverse of the Frisch elasticity, for the parameters governing the investment adjustment costs and capacity utilization costs we select a gamma distribution with a mean of 2, 4 and 5 respectively. The standard deviations of these distributions imply a wide prior distribution.

We specify values for steady-state inflation, GDP growth, the steady-state values of the debt-to-GDP ratio, the government purchases-to-GDP ratio and the tax-to-GDP ratio according to a normal distribution centered around the sample means.

We choose an beta distribution with mean 0.6 and a standard deviation of 0.2 for the autoregressive parameters, which are not related to government expenditures. In order to ensure

[16]Specifically, we use the item "U.S. Govt. obligations" and "Loans and investments" on a quarterly basis as above.

[17]Our results are robust to alternative values.

the identification of the short- and long-run components of government expenditures, we follow Bianchi and Ilut (2016) and specify a beta distribution with mean of 0.2 and a standard deviation of 0.05 for the autoregressive parameter of the short-run expenditure shock and the growth-rate of total factor productivity. The autoregressive coefficient of the long-run component is calibrated to 0.99. As prior distributions for the standard deviations of the structural shocks we employ inverted-gamma distributions and use the same mean and standard deviations as Bianchi and Ilut (2016) when using the same shocks. The prior of the investment specific shock has a mean of 10 with a standard deviation of 2 since previous literature usually finds large posterior means. The prior of the wage mark-up shock is centered at 2 with standard deviation 2. Furthermore, we calibrate the discount factor β to 0.995, the share of capital α to 0.3, the amount of habit h to 0.9 and the average maturity to its sample mean of 5 years.

Before we estimate the model, we verify that all parameters are identified locally, using the method by Iskrev (2010).[18]

3.3 Results

We approximate the posterior distribution of the estimated parameters using a random walk Metropolis-Hastings algorithm. We run two chains with 2,000,000 draws each. In order to assess convergence of the chains, we compute several measures following Brooks and Gelman (1998).[19] We find that the interval of the posterior distribution which is covered by the chains as well as the second moment of the posterior distribution are stable after approximately 1,000,000 draws. We report results based on every second draw of the last 250,000 draws of each chain.

The right panel of Table 1 reports the compares the posterior mode, mean and the 90-percent credible intervals. Most of our estimates of structural parameters are in line with the literature for similar kinds of medium-scaled DSGE models, e.g. Bianchi and Ilut (2016) or Justiniano, Primiceri, and Tambalotti (2013). In the Appendix we plot the prior and the posterior distribution of each parameter.

Our estimates indicate that the sample period is described by regime F. This finding is in line with Bianchi and Ilut (2016) and Davig and Leeper (2006). More precisely, we estimate the reaction coefficient of monetary policy on inflation smaller than 1 which implies a passive monetary policy regime. The estimated coefficient of the tax rate on the debt to GDP ratio might appear at first high with its mean of 0.05 for a fiscal authority which does not adjust taxes in order to stabilize outstanding debt. However, this is the coefficient on the tax rate and not on total taxes. Moreover, what matters for determinacy is the response of the government surplus. We estimate that government expenditures increase strongly whenever output falls (the reaction coefficient is roughly -0.6). Thus in total, the surplus does not sufficiently adjust to government debt in order to stabilize outstanding debt.

3.4 External validation

It is instructive to compare the predictions of the model with data which have not been used in the estimation. For this purpose, we display, in the left graph of figure 4, the share of public debt

[18] The results and statistics are available upon request.
[19] We provide the univariate convergence in the Appendix.

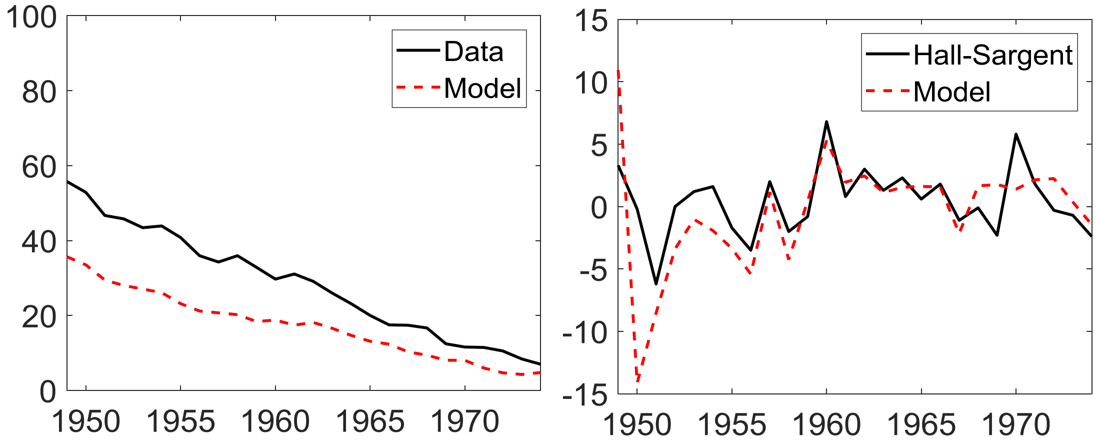

Figure 4: Data (solid line) vs model prediction (dashed line). Left panel shows share of public debt in banks' portfolio estimated (data source: Board of Governors), right panel shows return on government debt (data source: Hall and Sargent (2011)).

in the portfolio of the banking sector. The solid line represents the actual data, as provided by Board of Governors (see Section 3.1 above). During our sample period the share of debt declines from some 55 percent to less than 10 percent. The dashed line shows the model prediction for the share of public debt in the portfolio of the banking sector (Γ_t). While the model underpredicts the share of public debt at the beginning of the sample somewhat, the model predictions aligns fairly well with actual developments. Note that the time series was not used in the estimation and hence the model performance in this regard provides some external validation.

The right panel of Figure 4 shows the ex-post real return on government debt predicted by the model and contrasts it with a time series compiled by Hall and Sargent (2011). They use market prices for all marketable public bonds and calculate the (ex-post real) holding period return. Their measure thus captures changed in bond valuations which are not reflected in interest rate expenses computed on actual coupon payments. We find once more that the prediction of the model performs quite well.

Finally, we also compare the ownership structure of government debt in the model (households and financial institutions) to an empirical counterpart.[20] In principle US government debt is also held be foreign investors. However, the share of debt held by foreigners is very small in our sample period (approximately 6 percent). Regarding the debt holdings of households and the financial sector we find again that the model performs well. It predicts that about 20 percent of government debt were held by households (and 80 percent by financial institutions). This share is relatively stable during our sample period. In the data the share is 22 and 74 percent respectively.

[20]The empirical estimates are taken from table OFS-2 in the Treasury Bulletin, specifically from the volumes of December 1964, December 1979 and November 1982, published by the St. Louis Fed. The average share of household holdings is calculated as the share of total individuals relativ to total Federal securities outstanding. The average share of household (or foreign) holdings is calculated as the share of total individuals (Foreign and international) relative to total Federal securities outstanding.

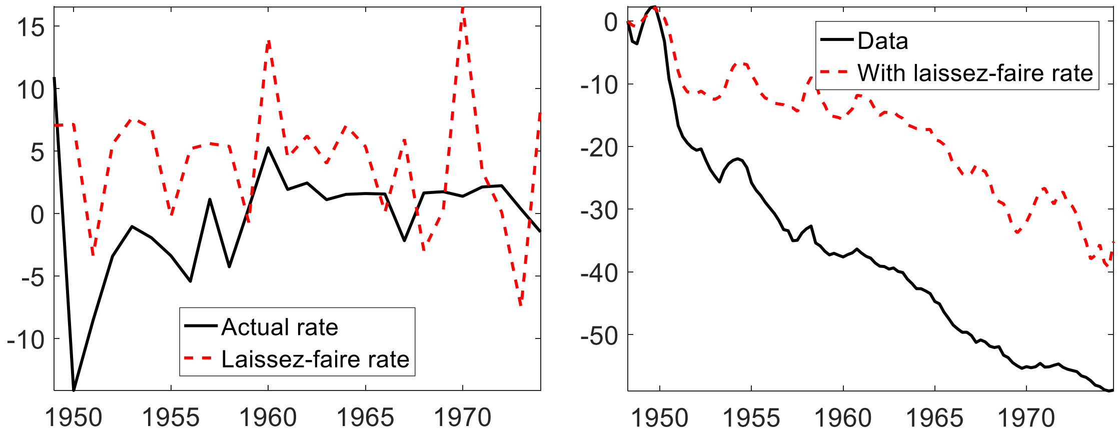

Figure 5: Repression in the US 1948–1974. Left panel shows actual (solid line) and laissez-faire (dashed line) interest rate (real, ex post); right panel shows actual evolution of debt-to-GDP ratio (solid line) and counterfactual evolution assuming the laissez-faire interest rate (dashed line).

4 Financial repression in the United States 1948–1974

We are finally in a position to address the questions that motivate our analysis: how large was financial repression during our sample period and what was its effect on macroeconomic performance? By construction the estimated model accounts for the strong decline of public debt during our sample period. However, as we argued above, the model also predicts the behavior of other important variables quite well, even though they have not been included in the estimation. We are thus confident that the estimated model allows us to answer these questions accurately.

In a first step towards quantifying the contribution of financial repression, we compute the laissez-fair interest rate, that is, the interest which would have prevailed in the absence of repression. We obtain it, as we turn to equation (2.7) and set $\tilde{\mu}_t$ to zero. The left graph of Figure 5 contrasts the laissez-faire interest to the actual interest rate, both measured from an ex post point of view in real terms. The laissez-faire rate exceeds the actual interest rate by several percentage points, notably in the early sample period. The gap between the two rates declines over time, but it is not trivial in most periods. This suggests that financial repression was sizeable, in line with the findings of Reinhart and Sbrancia (2015).

Put differently, our estimates suggests that the US government was able to borrow at artificially low interest rates. How strongly did this contribute to the reduction of public debt? There are different ways to approach this question. The first approach relies on simply accounting. Namely, we can compute the evolution of debt under the assumption that, all else equal, the government would have borrowed at the laissez-faire interest rate. The right graph of Figure 5 shows the result as it contrasts the evolution of debt under this assumption (dashed line) to the actual development (solid line). We find that while the actual decline of debt amounted to some 60 percentage points during our sample period, the decline would have been only about 35 percentage point if the government would have paid the laissez-faire rate. Hence, all else equal, the debt-to-GDP ratio would have been about 25 percentage points higher at the end of 1974.[21]

[21] Hall and Sargent (2011) consider the period 1945-74 during which public debt fell by 80 percentage points.

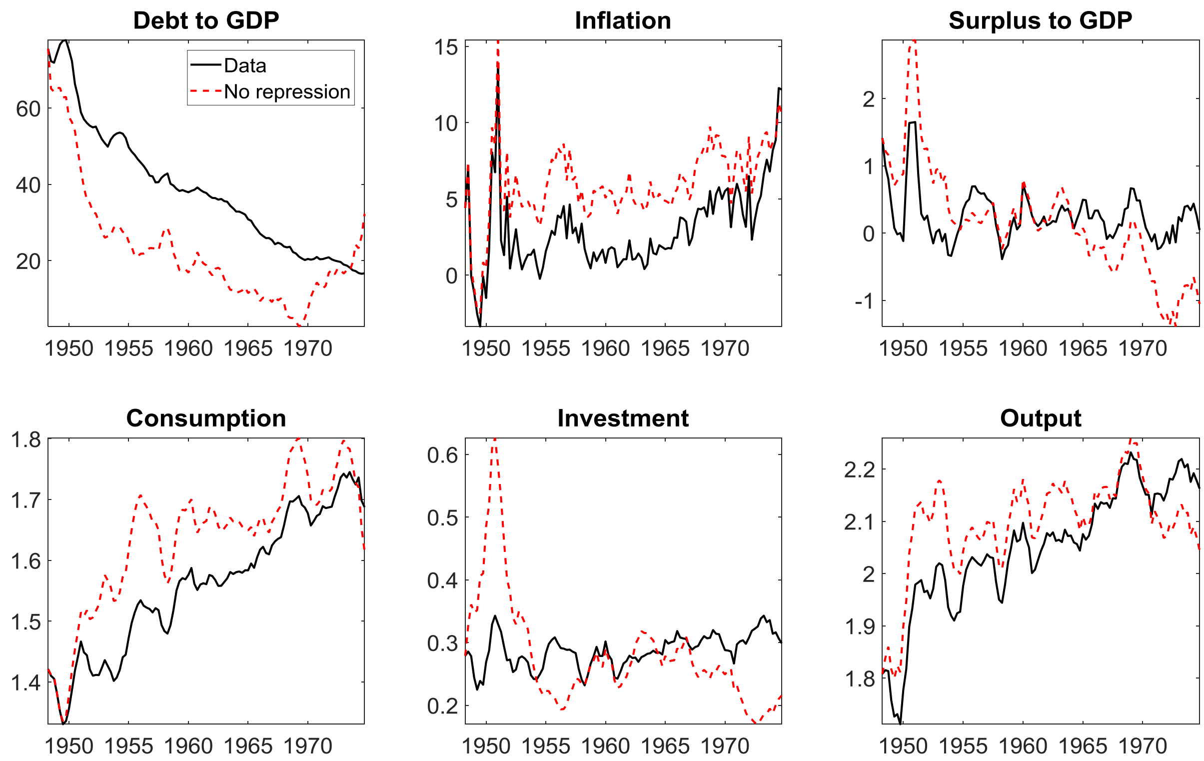

Figure 6: Actual time series (black solid line) vs. counterfactual outcome in the absence of repression (red dashed line).

However, it is unlikely that other things would have been equal because repression impacts not only public finances, but also the economy in general. We now develop a counterfactual scenario which accounts for this possibility. Specifically, we simulate a counterfactual scenario based on our model economy but we assume that there is no regulatory constraint. Otherwise we leave the model unchanged as we compute the equilibrium outcome. In particular, we assume that the model economy is exposed to the same shocks and governed by the same parameter and policy rules as the estimated model.

Figure 6 shows the results. It displays the behavior of four selected time series under the counterfactual (dashed line), contrasting it to the actual outcome (solid line). Two observations stand out. First, the debt-to-output ratio would have declined *faster* in the absence of repression. This result is perhaps surprising, but can be rationalized in light of the second observation: we find that, by and large, the economy would have been on a more expansionary path in the absence of repression.

Given our earlier discussion about the economy-wide effects of financial repression in section 2.6 above this is hardly surprising: financial repression distorts financial intermediation. It constrains banks in their ability to channel funds from households to firms. Confirming this insight, we find that in the counterfactual scenario, investment is much higher without repression. In addition, we observe that there is a consumption boom. This is to some extent the result of

Growth in real GDP and primary surpluses each contributed roughly 40 percent to the reduction of the debt-to-GDP ratio. 20 percent of the decline, however, were due to negative real returns. Note that our analysis differs in that we contrast the effect of repression by comparing actual interest rates to the laissez-faire interest rates (which is generally larger than zero).

an accommodating monetary-fiscal mix. Yet we find fairly similar results for a scenario where not only repression is absent, but where we also assume that monetary policy is active and fiscal policy is passive (see Figure 7 in the appendix).

Higher consumption and investment implies that output is higher as well as inflation. Lastly, we also observe that fiscal surpluses are higher in the counterfactual. Overall, these developments rationalize why public debt would have declined more strongly. In the absence of repression.

5 Conclusion

How large was financial repression in the US in the aftermath of WW2? We find that repression lowered the interest rate at which the government borrowed by several percentage points. The actual interest rate in our sample period was considerably lower than the laissez-faire rate. We define the laissez-faire rate as a counterfactual object: the interest which would have been observed in the absence of repression. We can recover it on the basis of our estimated model and it fluctuates over time just like the actual interest rate.

Did repression make an important contribution to the decline of public debt? Here the answer is: “it depends”. In an accounting sense the contribution was rather large. If we compute the evolution of public debt on the basis of the laissez-faire rate and keep everything else equal, the decline of the debt-to-GDP ratio during our sample period would have been less pronounced: the ratio would have declined by approximately 35, rather than by 60 percentage points. However, a full-fledged counterfactual should also take into account the broader implications of financial repression for economic performance. Once we do that, we find that repression *slowed down* the decline of public debt relative to output. This finding can be rationalized in light of the answer to a third question.

What was the impact of repression on the economy? Repression distorts financial intermediation and thus hampers investment and growth. We illustrate this effect through model simulations. For our counterfactual we also find that this effect has been large during our sample period. Absent repression the economy would have expanded more strongly and this is why the debt-to-GDP would have declined more strongly in the absence of repression.

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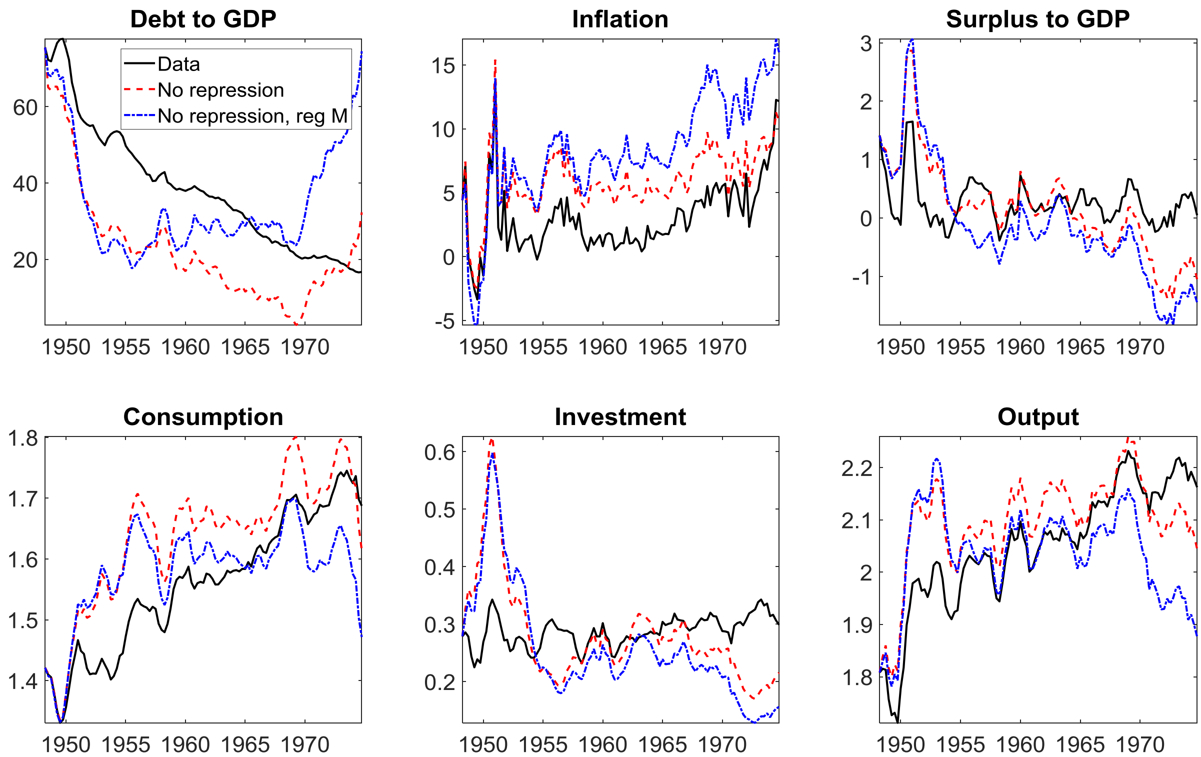

Figure 7: Actual time series (solid line) vs counterfactual outcome in the absence of repression (dashed line): alternative assumptions regarding monetary-fiscal policy mix.