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## Conference Paper

# Financial Repression in General Equilibrium

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# Financial Repression in General Equilibrium\*

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– *Preliminary draft* –

## 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 ex ante return on government debt by requiring banks to hold government debt. Repression thus 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 1948–1979 in order to quantify the extent of financial repression and its impact on the economy.

*Keywords:* Financial repression, government debt, Bayesian Estimation

*JEL-Codes:*

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# 1 Introduction

Financial repression allows a government to borrow at artificially low interest rates. This may be because of explicit or implicit ceilings on nominal interest rates and, hence, requires that the investor base is held captive through capital controls or other regulatory measures (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. And indeed, Figure 1 shows that real interest rates in the US has been rather low until the 1980s—notably long-term rates.

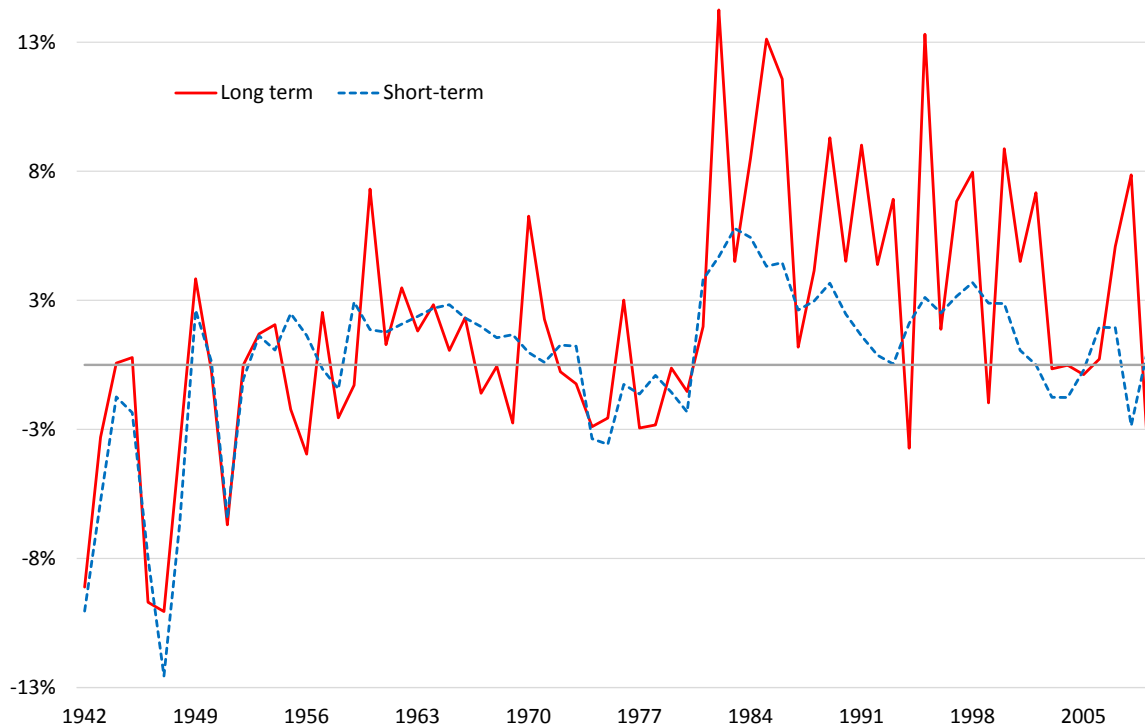
In this paper, we seek to quantify the extent of financial repression in the US during the post-WW2 period. Moreover, we ask how financial repression affects the macroeconomic performance of the US economy during that period. This question is pertinent given the rather spectacular build-up of public 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 inflation depressed, 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.

Quantifying the amount of revenue which is earned through the “repression tax” is challenging, because the interest rate which would prevail in the absence of repression, say, the “shadow interest rate”, is not directly observable. Earlier studies focused on developing countries. In this case one may proxy the shadow interest rate with the interest rate a government pays on world capital markets, as suggested by Giovannini and de Melo (1993). They document that financial repression contributed handsomely to government revenues.<sup>1</sup> An earlier survey by Fry (1997) concludes that financial repression contributed to government revenue in the order of 2 percent of GDP. 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 assumes a constant shadow interest rate of 3 percent.

In our analysis we rely on a dynamic general equilibrium model in order a) to estimate of the shadow 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 extended by a banking sector as in Gertler and Karadi (2011, 2013). The essential feature of our model is an additional constraint in the banking sector that permits the government to borrow long-term from financial institutions, even though it offers a yield which is below the shadow rate. We thus make explicit that the banking sector is a captive audience for government debt. In practise, our “regulatory constraint” reflects a variety of regulatory measures on which the

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<sup>1</sup>For a sample 24 countries during the period 1972–1987 Giovannini and de Melo (1993) estimate the average annual amount of revenue which is due to financial repression to amount to some 5 percent of GDP in several countries. The contribution of the repression tax to the total tax revenue is highest in Mexico, namely close to 40 percent.



**Figure 1:** Real interest rates. Notes: solid line is real return on marketable debt of government portfolio computed by Hall and Sargent (2011); average maturity varies between 2.5 and 9 years during sample period; dashed line is ex-post real return on three month T-bills (source: St. Louis Fed).

government may rely, if only unintendedly, when it auctions off its debt at elevated prices.

In our model, the yield on long-term debt differs from short-term interest rates on deposit because of two distinct factors. First, there is a term premium because of market segmentation (see Fuerst, 2015). Long-term debt is only held by financial institutions which are leverage constrained and thus unable to arbitrage away yield differences between short- and long-term rates. A tighter leverage constraint, say because of reduced net worth, all else equal raises the difference between short-term and long-term rates. Second, financial repression, all else equal, lowers this difference as the government engineers a reduction in long-term yields. As illustrated by Figure 1 the difference between short-term and long-term interest rates is quite small in the post-WW2 period. This is consistent with the notion that financial repression undid most of the term premium.<sup>2</sup>

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 investment is channeled through banks. As repression hurts the net worth of leverage-constrained banks, investment declines and so does output and inflation. We also contrast financial repression with conventional monetary policy measures. Monetary policy may lower real interest rate by not responding aggressively to inflation. Such a conduct of US monetary policy has been documented for the

<sup>2</sup>Estimates of the term premium (which do not account for repression) also tend to show a strong increase at the beginning of the 1980s (Adrian et al., 2015).

post-WW2 period (Clarida et al., 2000). Importantly, however, monetary policy differs from financial repression in that it impacts short and long term real interest rates alike—it gets, as is well known, in all the cracks.

We estimate the model on quarterly US time series data for the period 1948–1979. We find that repression contributed handsomely to the reduction of US government debt-to-GDP ratio during this period.<sup>3</sup> We also establish through counterfactual experiments that inflation would have been higher in the absence of repression.

The rest of the paper is structured as follows. Section 2 outlines the model. Section 3 describes the estimation and the results. We compute counterfactual outcomes in Section 4. A final section concludes.

## 2 The Model

Our analysis is based on a medium-scale New Keynesian model that combines a detailed fiscal sector and a banking sector. The model builds on earlier work by Bianchi and Ilut (2016), Justiniano et al. (2013) and Gertler and Karadi (2011, 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 representative household which supplies work, consumes and saves. Following Gertler and Karadi (2011, 2013), we assume that within a household there is a fraction  $f$  of household members which are bankers and a fraction  $1 - f$  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 government bonds. It may also (be forced to) hold government debt. 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 exists its business, retained earnings are transferred to the household and the bank shuts down. Any new banker obtains a startup fund,  $H_t$ , 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.

Each household maximizes lifetime utility subject to a budget constraint. As it can trade a complete set of state-contingent claims, we state the equations in terms of a representative household. Denote with  $c_t$ ,  $d_t^b$  and  $h_t$  the family consumption, deposits and labor supply,

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<sup>3</sup>Hall and Sargent (2011) consider the period 1945-74 during which public debt fell by 80 percentage points. 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 shadow interest rates (which is generally larger than zero)

respectively, the objective is given by

$$\max_{c_t, d_t^b, h_t} \sum_{t=0}^{\infty} \beta^t e^{\eta_{d,t}} E_0 \left( \log(c_t - hc_{t-1}^a) - \chi_h \frac{h_t^{1+\varphi}}{1+\varphi} \right)$$

subject to the budget constraint

$$c_t + d_t^b \leq (1 - \tau_t) (w_t h_t + d_t^{firms}) + \tau_t^{tr} + R_t^d d_{t-1}^b - H_t.$$

We also rule out Ponzi games. We assume (external) consumption habits and  $c_t^a$  denotes the average consumption in the economy.  $P_t$  is the aggregate price index,  $\tau_t$  the average tax rate,  $w_t$  the real wage,  $d_t^{firms}$  are dividends which accrue to households who own the different firms (see below).  $\tau_t^{tr}$  are transfers,  $R_t^d$  is the gross real return on deposits, a compositum of short-term nominal interest rate and the inflation rate which will be defined below.  $\eta_t^b$  is a preference shock which follows an AR(1) process:

$$\eta_t^b = \rho_b \eta_{t-1}^b + \varepsilon_t^b \text{ with } \varepsilon_t^b \sim N(0, \sigma_b^2).$$

Optimality requires the following first order conditions to be satisfied

$$c: \quad \lambda_t = \frac{e^{\eta_t^d}}{c_t - hc_{t-1}^a} \quad (2.1)$$

$$D^b: \quad 1 = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}} R_t \quad (2.2)$$

$$h: \quad e^{\eta_t^d} \chi_h h_t^\varphi = \lambda_t (1 - \tau_t) w_t \quad (2.3)$$

where  $\lambda_t$  denotes the Lagrange-Multiplier on the budget constraint. We define the households stochastic discount factor  $\Lambda_{t,t+k}$  as follows:

$$\Lambda_{t,t+k} = \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}}. \quad (2.4)$$

## 2.2 Financially repressed banks

A generic bank uses deposits and retained earnings to purchase two types of assets, namely shares in non-financial firms and long-term government debt. We use  $s_t$  to denote the bank's shares of the intermediate good firm (see below), valued at price  $q_t$ , quoted in consumption goods. We use  $b_t^l$  to denote the stock of government debt held by the bank and  $p_t^l$  its real price. Denote with  $n_t$  the banks equity position (or net worth), the balance sheet of the banker is thus given by

$$q_t s_t + p_t^l b_t^l = d_t^b + n_t.$$

Here  $P_t^l$  denotes the price of newly issued long-term government debt. To simplify the analysis we follow Woodford (2001) and assume that government debt issued in period  $t$  offers the following payment stream  $\{1, \rho, \rho^2, \rho^3, \dots\}$ . Here, the decay factor  $\rho$  captures the average maturity of such a bond. Under these assumptions it is not necessary to model a complete portfolio of outstanding bonds. In the absence of arbitrage across different maturities and given  $P_t^l$ , the price of a bond issued in period  $t - k$  is given by  $\rho^k P_t^l$ . The ex post yield of holding long-term government debt

in real terms is given by

$$R_t^l = \frac{\frac{1}{\bar{P}_t} + \rho p_t^l}{p_{t-1}^l}.$$

Let  $R_{t+1}^k$  denote the real return of investing in shares such that net worth evolves as follows

$$\begin{aligned} n_{t+1} &= R_{t+1}^k q_t s_t + R_{t+1}^l p_t^l b_t^l - R_{t+1}^d d_t^d, \\ &= \left( R_{t+1}^k - R_{t+1}^d \right) q_t s_t + \left( R_{t+1}^l - R_{t+1}^d \right) p_t^l b_t^l + R_{t+1}^d n_t \end{aligned} \quad (2.5)$$

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

$$V_t = \sum_{k=1}^{\infty} (1 - \sigma) \sigma^{k-1} E_t \Lambda_{t,t+k} n_{t+k} \quad (2.6)$$

As in Gertler and Karadi (2011, 2013) we assume that depositors face the risk that bankers divert a fraction  $\theta$  of its shares and a fraction of  $\Delta\theta$  of its holding of government debt, where  $\Delta < 1$ . In other words, shares are easier to divert, because their value is harder to observe by depositors. Therefore, a household is only willing to deposit in that bank if the following incentive constraint is fulfilled:

$$V_t \geq \theta q_t s_t + \Delta \theta p_t^l b_t^l. \quad (2.7)$$

In addition, to capture a variety of regulatory measures we impose a regulatory constraint

$$p_t^l b_t^l \geq b_t^{min}. \quad (2.8)$$

In other words, the real value of government held by the banking sector must not be lower than  $b_t^{min}$  which is thus an additional policy instrument in our setup. We think of the 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 amount of government debt. Still these measures effectively raise the price of government debt. As we show below, this is precisely the implication of constraint (2.8).

A generic banker maximizes (2.6) subject to (2.5), (2.7) and (2.8). Optimality requires the following conditions to be satisfied:

$$E_t \tilde{\Lambda}_{t,t+1} \left( R_{t+1}^k - R_{t+1}^d \right) = \frac{\zeta_t}{1 + \zeta_t} \theta, \quad (2.9)$$

$$E_t \tilde{\Lambda}_{t,t+1} \left( R_{t+1}^l - R_{t+1}^d \right) = \Delta \frac{\zeta_t}{1 + \zeta_t} \theta - \mu_t, \quad (2.10)$$

Here  $\zeta_t$  and  $\mu_t$  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 (2.9) relates the (expected) excess return of investing in non-financial firms (relative to the deposit rate) to the tightness of the incentive constraint (2.7). Intuitively, to the extent that bankers are leverage constrained expected excess yields persist in equilibrium.

Equation (2.10), in turn, relates the (expected) excess return of investing in government debt

(relative to the deposit or short-term interest rate) to the tightness of the incentive constraint. As argued by Fuerst (2015) market segmentation is a way to rationalized the term premium. In our setup, because only leverage-constrained financial firms hold government debt long-term yields tend to elevated relative to deposit rates. Yet, in addition to the excess-return component (or “term premium”), there is a “regulatory discount”. Indeed, as equation (2.10) shows, the tighter the regulatory constraint (2.8), the lower the expected excess return on long-term debt. Intuitively, because the regulation constraint binds, (expected) yields on long-term government are depressed—banks are unable to sell long-term bonds which stabilizes their price at an artificially high level.

It is instructive to consider a version of complementary slackness condition associated with the regulatory constraint (2.8)

$$E_t \left\{ \tilde{\Lambda}_{t,t+1} \left( R_{t+1}^l - \tilde{R}_{t+1} \right) \right\} \left( p_t^l b_t^l - b_t^{min} \right) = 0. \quad (2.11)$$

Here  $\tilde{R}_{t+1}$  is the shadow yield on long-term government debt which would obtain if the regulation constraint were slack ( $\mu_t = 0$ ). This expression shows that whenever there is financial repression, that is, whenever  $R_{t+1}^l < \tilde{R}_{t+1}$ , the regulation constraint must bind. In our analysis below we thus assume that the regulation constraint binds throughout. Of course, the extent of repression may vary over time.

Following Gertler and Karadi we also assume that the incentive constraint binds always. It is then possible to the define the leverage ratio  $\phi_t$  as follows

$$q_t s_t + p_t^l b_t^l = \phi_t n_t \quad (2.12)$$

where

$$\phi_t = \frac{E_t \tilde{\Lambda}_{t,t+1} R_{t+1}^d}{\theta - E_t \tilde{\Lambda}_{t,t+1} (R_{t+1}^k - R_{t+1}^d)}. \quad (2.13)$$

The leverage ratio falls in  $\theta$ , 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  $E_t \tilde{\Lambda}_{t,t+1} (R_{t+1}^k - R_{t+1}^d)$ , since that increases the value of staying a banker. Similarly, the leverage ratio rises with the discounted deposit rate  $E_t \tilde{\Lambda}_{t,t+1} R_{t+1}^d$  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 follows

$$\tilde{\Lambda}_{t,t+1} \equiv \Lambda_{t,t+1} \Omega_{t+1} \quad (2.14)$$

where

$$\Omega_{t+1} = 1 - \sigma + \sigma \frac{\partial V_{t+1}}{\partial n_{t+1}} \quad (2.15)$$

with

$$\frac{\partial V_t}{\partial n_t} = E_t \tilde{\Lambda}_{t,t+1} \left[ \left( R_{t+1}^k - R_{t+1}^d \right) \phi_t + R_{t+1}^d \right] \quad (2.16)$$

This implies that the excess return is not only weighted with the stochastic discount factor but also with the probability weighted marginal increase in net-worth.



Since both constraints are always binding we arrive at

$$V_t = \theta q_t s_t + \Delta \theta p_t^l b_t^l \quad (2.17)$$

and

$$p_t^l b_t^l = b_t^{min} \quad (2.18)$$

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

$$n_t = \sigma \left[ (R_t^k - R_t^d) q_{t-1} s_{t-1} + (R_t^l - R_t^d) p_{t-1}^l b_{t-1}^l + R_t^d n_{t-1} \right] + H_t \quad (2.19)$$

## 2.3 Firms

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

### 2.3.1 Intermediate good firms

Intermediate good firms use labor and capital as input to produce a good that they sell to final good firm. The representative intermediate good firm operates the following production function

$$y_t = (k_t^s)^\alpha (Z_t h_t(j))^{1-\alpha}, \alpha \in (0, 1).$$

Here  $k_t^s$  represents capital services. Given utilization  $u_t$  and the predetermined capital stock  $k_{t-1}$  they are given by

$$k_t^s = u_t k_{t-1}. \quad (2.20)$$

$Z_t$  represents exogenous labor-augmenting technological progress. The level of that neutral technology is non-stationary and its growth rate,  $\eta_{z,t} \equiv \Delta \log Z_t$ , follows an AR(1) process

$$\eta_{z,t} = \gamma + z_t, \quad z_t = \rho_z z_{t-1} + \sigma_z \varepsilon_{z,t}, \rho_z < 1, \varepsilon_{z,t} \sim N(0, 1). \quad (S.3)$$

The timing is as follows: After production took place, the intermediate good firm purchases the new capital stock from the capital goods producer  $k_t$  for price  $q_t$ . To finance this acquisition it issues  $s_t$  shares for the price  $q_t$ . Thus it holds  $q_t s_t = q_t k_t$ .

Profits are given by

$$P_t^m y_t - w_t n_t - Z_t^k k_{t-1} - \Psi(u_t) k_{t-1}.$$

Here  $P_t^m$  denotes the price of intermediate goods and  $\Psi(\cdot)$  the cost of capital utilization. Optimality requires

$$h : \quad w_t = P_t^m (1 - \alpha) \frac{Y_t}{h_t}$$

$$u : \quad \alpha P_t^m \frac{y_t}{u_t} = \Psi'(u_t) k_{t-1}$$

$$k : \quad \alpha P_t^m \frac{y_t}{k_{t-1}} - \Psi(u_t) = Z_t^k$$

We can thus determine the return a bank gets on an investment in capital as follows

$$R_t^k = \frac{Z_t^k + (1 - \delta) q_t}{q_{t-1}} \quad (2.21)$$

### 2.3.2 Retailers

There is a continuum of monopolistically competitive retailers which repackage and diversify intermediate goods. Eventually these goods constitute a CES-bundle, the final good:

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

with  $\omega_{p,t}$  varies exogenously. Retailer transform one unit of intermediated goods into one unit of differentiated good. Hence, its marginal costs is given by  $P_t^m$ . Adjusting prices is costly. A generic retailer  $j$  faces quadratic adjustment costs:

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

with  $\Pi_t = \frac{P_t}{P_{t-1}}$ .

Retailers set prices in order to maximize life-time profits:

$$\begin{aligned} \max_{P_t(j)} E_t \sum_{k=0}^{\infty} \underbrace{\Lambda_{t,t+k}}_{\Lambda_{t,t+k}^\tau} (1 - \tau_{t+k}) \left\{ \left( \frac{P_{t+k}(j)}{P_{t+k}} - P_{t+k}^m \right) y_{t+k}(j) - ac_{t+k}(j) \right\} \\ s.t. \quad y_{t+k}(j) = \left( \frac{P_{t+k}(j)}{P_{t+k}} \right)^{-\frac{1+\omega_{p,t+k}}{\omega_{p,t+k}}} y_{t+k} \end{aligned}$$

Optimality requires the following condition to be satisfied

$$\begin{aligned} -\frac{1}{\omega_{p,t}} + P_t^m \frac{1 + \omega_{p,t}}{\omega_{p,t}} - \varphi \left( \Pi_t - \Pi_{t-1}^\xi \Pi^{1-\xi} \right) \Pi_t + \frac{1 + \omega_{p,t}}{\omega_{p,t}} \frac{\varphi}{2} \left( \Pi_t - \Pi_{t-1}^\xi \Pi^{1-\xi} \right)^2 + \\ \frac{\Lambda_{t,t+1}^\tau}{\Lambda_{t,t}^\tau} \varphi \left( \Pi_{t+1} - \Pi_t^\xi \Pi^{1-\xi} \right) \Pi_{t+1} \frac{y_{t+1}}{y_t} = 0. \end{aligned} \quad (2.22)$$

### 2.3.3 Capital producer firm

Capital producer use final output from the retail firms to build new capital goods  $x_t$  which they sell to the intermediate good firms. Any profits, which can arise due to the adjustment costs, are distributed to the household sector.

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

FOC:

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

If there are no adjustment costs, i.e.  $X[\cdot] = X'[\cdot] = 0$ , then  $q_t = \frac{1}{e^{\eta_{x,t}}}$ , i.e. the marginal Tobin's  $Q$  is equal to the replacement cost of capital (the relative price of capital). If in addition  $\eta_{x,t} = 0, q_t = 1$  as in the neoclassical growth model. The stock of capital evolves as

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

## 2.4 Government

For the government budget constraint we largely follow the exposition by Bianchi and Ilut (2016). The government raises taxes and issues long-term bonds to finance its expenditures, which consist of transfers, returns on outstanding debt and purchases:

$$R_t^l p_{t-1}^l b_{t-1}^l + T_t^{tr} + G_t = p_t^l b_t^l + T_t$$

Dividing the constraint by real GDP  $y_t$  and denoting the debt to GDP ratio by  $d_t = \frac{p_t^l b_t^l}{y_t}$ , we arrive at

$$R_t^l d_{t-1} \frac{y_{t-1}}{y_t} + e_t = d_t + \tau_t \quad (2.23)$$

where  $e_t$  is the expenditure ratio (transfers and purchases) relative to GDP. As Bianchi and Ilut (2016) we decompose total expenditures into a short-term component  $e_t^s$  and a long-term component  $e_t^l$ . The long-term component will be completely exogenous and governs 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. In linearized form these variables are given by:

$$\tilde{e}_t^l = \rho_e^l \tilde{e}_{t-1}^l + \varepsilon_t^{e^l} \quad (S.4)$$

$$\tilde{e}_t^s = \rho_e^s \tilde{e}_{t-1}^s + (1 - \rho_e^s) \phi_y \hat{y}_t + \varepsilon_t^{e^s} \quad (S.5)$$

The ratio of purchases  $G_t$  relative to expenditures  $E_t$  is given by:

$$\zeta_t = \frac{G_t}{E_t}, \text{ with } g_t = \frac{1}{1 - \varsigma_t}, \varsigma_t = \frac{G_t}{y_t} \Rightarrow \zeta_t = \frac{g_t - 1}{g_t e_t} \quad (2.24)$$

and evolves according to

$$\tilde{\zeta}_t = \rho_\zeta \tilde{\zeta}_{t-1} + (1 - \rho_\zeta) \phi_y^\zeta \hat{y}_t + \varepsilon_t^\zeta \quad (S.6)$$

The ratio of taxes to GDP given by

$$\tilde{\tau}_t = \rho_\tau \tilde{\tau}_{t-1} + (1 - \rho_\tau) (\phi_d \tilde{d}_t + \phi_y^\tau \hat{y}_t) + \eta_{\tau,t} \quad (2.25)$$

with

$$\eta_{\tau,t} = \sigma_\tau \varepsilon_{\tau,t}, \varepsilon_{\tau,t} \sim N(0, 1) \quad (S.7)$$

Finally, monetary policy is conducted by following an interest rate rule

$$\frac{R_t^s}{R^s} = \left( \frac{R_{t-1}^s}{R^s} \right)^{\rho_r} \left( \left( \frac{\Pi_t}{\bar{\Pi}} \right)^{\phi_\pi} \right)^{1 - \rho_r} e^{\eta_{r,t}} \quad (2.26)$$

$$R_{t+1}^d = \frac{R_t^s}{\Pi_{t+1}} \quad (2.27)$$

$$\eta_{r,t} = \sigma_r \varepsilon_{r,t}, \varepsilon_{r,t} \sim N(0, 1). \quad (\text{S.8})$$

## 2.5 Aggregation and solution

Aggregate demand is given by combining the household and the government budget constraint and firms profits:

$$\frac{y_t}{g_t} = c_t + e^{-\eta_{x,t}} \left[ 1 + X \left[ \frac{x_t}{x_{t-1}} \right] \right] x_t + \frac{1}{2} \varphi \left[ \Pi_t - \Pi_{t-1}^\xi \Pi^{1-\xi} \right]^2 y_t + \Psi(u_t) k_{t-1} \quad (2.28)$$

Most variables inherit the non-stationarity of the technological progress  $Z_t$ . We therefore re-scale the equilibrium conditions into stationary variables relative to the trend and linearize the model around its non-stochastic steady state.

## 2.6 Transmission

In what follows we develop some intuition for how financial repression impacts the economy. For this purpose we consider a scenario where the economy is initially off steady state: government debt exceeds its long-run value by one percent. For the present scenario we also assume that  $\Delta = 0$ , that is, banks can not divert government debt and that taxes are lump-sum only. Note that repression impacts equilibrium dynamics quite generally. Still its effect is most dramatic when it comes to fiscal impulses.

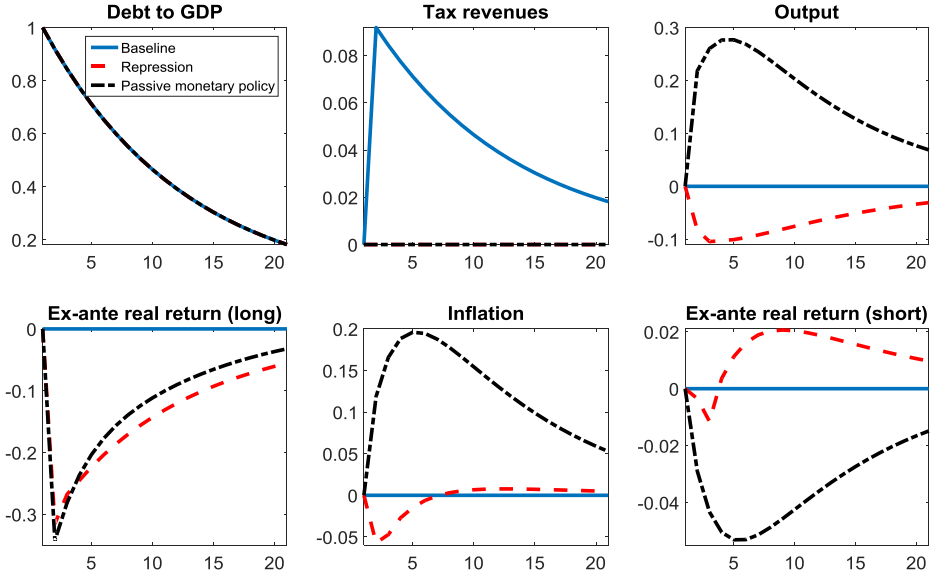
Figure 2 illustrates the adjustment dynamics assuming that government debt exceeds its steady state level. Horizontal axes measure time in quarters. Vertical axes measure deviations from steady state. We consider three different cases. In the first case, to set the stage, we assume that there is no repression and that taxes are lump-sum. For debt to decline (shown in the upper-left panel), taxes increase temporarily (upper-middle panel). Apart from taxes all variables remain unchanged (at their steady state level). In this case, it turns out that government debt is neutral—an instance where the Ricardian Equivalence proposition applies.<sup>4</sup>

In the presence of repression, dynamics differ considerably. Taxes are kept constant, but long-term government yields decline (lower-left panel). This is now the key to reduce government debt which is no longer neutral. In fact, the depressed yields act like a tax on bankers' net worth. As a result lending and investment decline, as does economic activity (upper-right panel). As employment declines, so do marginal costs. Higher government debt is deflationary under repression—at least initially (lower-middle panel). The path of short-term rates reflects the behavior of monetary policy which is assumed to be active (lower-right panel).

In a last experiment we modify this assumption. We assume that monetary policy is passive instead while fiscal policy is active, that is, it is not sufficiently responsive to debt so as to stabilize debt. To stabilize the real value of debt inflation adjusts (which is possible given passive monetary policy). This is, in other words, a world where the fiscal theory of the price level reigns. To make things transparent we abstract from repression once again. Interestingly, the dynamics of government yields are quite comparable to the previous scenario with repression.

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<sup>4</sup>In our model Ricardian equivalence fails even if taxes are lump sum whenever  $\Delta > 0$ . Yet quantitatively the effect of debt on the economy is small.



**Figure 2:** Alternative scenarios for debt reduction. Notes: solid line corresponds to lump-sum taxes only, dashed line: model mit repression; dashed-dotted line: passive monetary policy/no repression.

Now, however, long-rates move in close sync with short term rates. Key is now that monetary policy lets inflation take off, this lower real rates, both short and long—and, in the event, also suffices to stabilize the real value of debt.

### 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 eight series of US quarterly data from 1948Q2–1979Q3: real per capita GDP growth, the growth rate of private investment, the inflation rate, the nominal interest rate, the market value of debt to GDP, the government expenditure to output ratio, the tax revenue to output ratio and the share of purchases.

Real per capita GDP growth is the first difference of the log of real per capita GDP which is nominal GDP divided by population and the GDP deflator. We follow Leeper et al., 2010 in constructing the population series. GDP deflator (Table 1.1.4, line 1) and nominal GDP (Table 1.1.5, line 1) are taken from NIPA. The inflation rate is the quarterly log difference of the GDP deflator. Since the Federal Reserve started targeting a specific rate only from June 1954, nominal interest rates are given first by the secondary market rate of the 3m Treasury Bill until 1954Q2 and thereafter by the effective Federal Funds rate.<sup>5</sup>

<sup>5</sup>Both rates are not completely identical but follow a very close pattern as demonstrated by a correlation coefficient of 0.98 for 1954Q3 to 1979Q3.

We take the market value of debt from Cox and Hirschhorn (1983) which is published by the Federal Reserve Bank of Dallas. We concentrate on the market value rather than the nominal value to capture revaluation effects and to study the amount of economic resources the government needs to finance its debt. Government expenditures are the sum of government purchases and transfers. The former is given by the sum of consumption expenditure (Table 3.2, line 21), gross government investment (Table 3.2, line 41), net purchases of non-produced assets (Table 3.2, line 43), minus consumption of fixed capital (Table 3.2, line 44). 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). Tax revenues are given by the difference between current receipts (Table 3.2, line 37) and current transfer receipts (Table 3.2, line 16). The fiscal variables are divided by nominal GDP. The share of purchases is transformed to be consistent with  $g_t$  in the model. The observation equations of the model are given by the following equations:

$$\begin{bmatrix} \text{dlGDP}_t \\ \text{dlInvestment}_t \\ \text{dlGDPDeflator}_t \\ \text{dlInterestRate}_t \\ \text{GovDebtRatio}_t \\ \text{ExpenditureRatio}_t \\ \text{TaxRatio}_t \\ \text{PurchaseRatio}_t \end{bmatrix} = 100 \cdot \begin{bmatrix} \gamma \\ \gamma \\ \log(\Pi) \\ \log(e^\gamma \Pi / \beta) \\ d \\ e \\ \tau \\ \log(g) \end{bmatrix} + \begin{bmatrix} \hat{y}_t - \hat{y}_{t-1} + \tilde{\eta}_t^z \\ \hat{x}_t - \hat{x}_{t-1} + \tilde{\eta}_t^z \\ \hat{\pi}_t \\ \hat{r}_t \\ \tilde{d}_t \\ \tilde{\eta}_t^e \\ \tilde{\tau}_t \\ \hat{g}_t \end{bmatrix}$$

where dl is 100 times the log difference of each variable while the rest is just the observed data expect  $\text{PurchaseRatio}_t$  which is set to be consistent with  $g_t$ . Here, hat ( $\hat{\cdot}$ ) denotes the log-deviation and tilde ( $\tilde{\cdot}$ ) the linear deviation from steady state. The estimation sample starts in 1948Q2 because the population series only goes back until 1948. We end in 1979Q3 with the appointment of Paul Volcker as Chairmen of the Federal Reserve Board. First, this period is characterized by a large reduction in the debt to GDP ratio from 72.5% to 18.8%. Second, the period afterwards marks a shift in the conduct of monetary policy, see for example Clarida et al. (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 et al. (2013) and Bianchi and Ilut (2016). An overview of the specification of the prior distribution can be found in table 1.

More precisely, we specify 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 a normal distribution centered around their respective sample means. 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. 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.

We choose an beta distribution with mean 0.5 and a standard deviation of 0.2 for the autoregressive parameters, which are not related to government expenditures. In order to ensure 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. The autoregressive coefficient is calibrated to 0.99. As prior distributions for the standard deviations of the structural shocks we employ inverted-gamma distributions. Furthermore, we set the discount factor  $\beta$  to 0.995, the share of capital  $\alpha$  to 0.3, the amount of habit  $h$  to 0.9 and the average maturity to its sample mean of 5 years.

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,  $\phi_\pi$ , is a normal distribution centered around 1 with a standard deviation of 0.3. The prior distribution of the coefficient on debt in the tax rule,  $\tau_d$ , is a normal distribution with mean 0 and a standard deviation of 0.1. 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.

Finally, the amount of repression  $\mu$  in steady state has a gamma distribution with mean 0.5 and standard deviation of 0.2. The mean was chosen to imply 2% repression in steady state, which is in line with Reinhart and Sbrancia (2015).

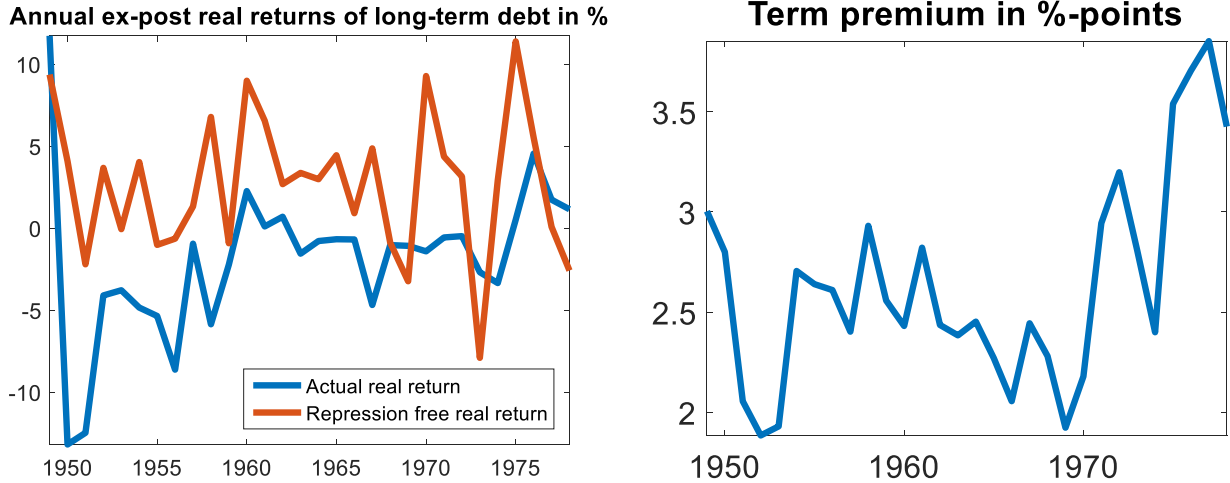
### 3.3 Posterior distribution

Beforehand the estimation we verify that the parameters are identified locally, using the method by Iskrev (2010). We approximate the posterior distribution of the estimated parameters using a standard Metropolis-Hastings algorithm. We run two chains with 2,500,000 draws each. In order to assess convergence of the chains, we compute several measures following Brooks and Gelman (1998).<sup>6</sup> 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. Table 1 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 et al. (2013). In Appendix B 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

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<sup>6</sup>We provide the univariate convergence in Appendix B.



**Figure 3:** Interest rates: estimated times series. Notes: left panel shows actual vs shadow interest rate on government debt (in real terms); right panel shows estimated term premium.

reaction coefficient of monetary policy on inflation smaller than 1 and find a negative response of the tax ratio on deviations of debt to GDP from steady state. The estimated size of financial repression is above the prior mean, the size is not sufficiently high to render fiscal policy passive.

## 4 Counterfactuals

The estimated model allows us to determine a number of counterfactual objects which are of particular interest. We first report our estimate for the shadow interest rate. The left panel of Figure 4 displays the result and contrasts our estimate of the shadow interest rate with our estimate of the actual long-term interest rate. Both series are measured in real terms. There is a sizeable gap, notably at the beginning of the sample. Financial repression, in other words, was strong.

We also use the model to decompose the excess return on long-term government debt into the term-premium and the regulatory discount. The right panel of Figure displays our estimate for the term premium. The magnitude is higher than in the literature like Adrian et al., 2015, however, this stems from the fact that repression during that time was positive.

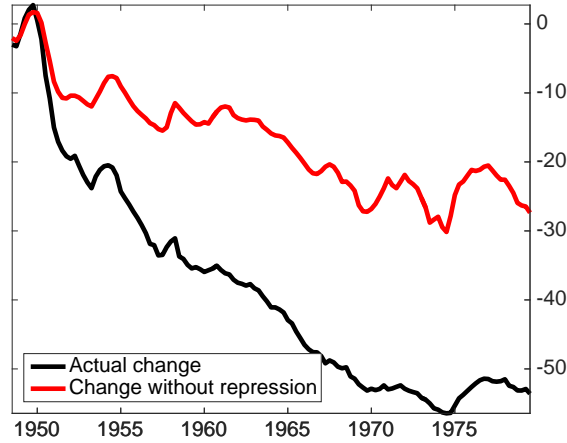
Financial repression allowed the US government to borrow at artificially low rates. This had implication for the evolution of the debt to GDP ratio. In order to quantify its impact, we can compute the evolution of government debt assuming—all else equal—that the government would have borrowed at the shadow interest rate. Figure shows the results. Had the government paid the shadow rate rather than the actual rate, the debt-to-GDP ratio would have been about 25 percentage points higher at the end of 1979.

However, it is unlikely that other things would have been equal. To capture this notion we simulate a counterfactual economy without financial repression, but exposed to the same shocks and governed by the same parameter and policy rules as our estimated economy. This implies in particular a passive monetary policy and an active fiscal policy (Regime F). Figure 5 displays



**Table 1:** Estimation results posterior mean

		Dist	Prior		Posterior			
			Mean	SE	Mode	Mean	5 percent	95 percent
$100\mu$	Repression	G	0.50	0.20	0.8532	0.8663	0.4478	1.2887
$\phi_\pi$	MP on inflation	N	1.00	0.50	0.6781	0.4973	0.0694	0.9666
$\tau_d$	Tax on debt	N	0	0.10	-0.0096	-0.0101	-0.0170	-0.0034
$\phi_y$	MP on output	G	0.25	0.10	0.1951	0.2207	0.0796	0.3547
$\rho_r$	AR(1) mp	B	0.50	0.20	0.9770	0.9758	0.9624	0.9905
$\rho_\tau$	AR(1) tax	B	0.50	0.20	0.7789	0.7928	0.7219	0.8679
$\iota_y$	Exp share on y	N	0.10	0.20	0.1061	0.1029	-0.2367	0.4259
$\phi_y^{es}$	SR-exp on y	N	0.20	0.40	-0.5768	-0.6161	-0.7515	-0.4752
$\xi^\pi$	Price indexation	B	0.50	0.15	0.3773	0.4184	0.1443	0.6890
$\xi^w$	Wage indexation	B	0.50	0.15	0.5557	0.5470	0.3327	0.7535
$\kappa^\pi$	NKPC-slope	G	0.30	0.15	0.0228	0.0306	0.0058	0.0551
$\theta^w$	Wage adjustment	B	0.66	0.10	0.7585	0.7595	0.6825	0.8374
$\varphi$	Frisch elasticity	G	2.00	0.25	2.0019	2.0290	1.6165	2.4290
$\varkappa$	Inv. adjustment	G	4.00	1.00	1.8804	1.9041	1.5903	2.2277
$\kappa$	Utilization cost	G	5.00	1.00	4.8834	5.0399	3.4060	6.6379
$100\pi$	Inflation	N	0.90	0.05	0.9184	0.9185	0.8370	0.9976
$100\gamma$	Growth	N	0.56	0.05	0.5705	0.5684	0.4939	0.6444
$d$	Debt to GDP	N	1.40	0.20	1.5772	1.5809	1.2998	1.8529
$g$	Purchases	N	1.12	0.01	1.1155	1.1158	1.1048	1.1263
$\tau$	Tax revenue	N	0.17	0.01	0.1697	0.1699	0.1655	0.1743
AR(1) shocks								
$\rho_x$	Investment	B	0.60	0.20	0.7175	0.7153	0.6375	0.7929
$\rho_\zeta$	Exp. share	B	0.60	0.20	0.9830	0.9801	0.9660	0.9950
$\rho_z$	Tfp	B	0.20	0.05	0.2776	0.2860	0.1897	0.3854
$\rho_d$	Demand	B	0.60	0.20	0.8311	0.8047	0.7096	0.9015
$\rho_{e^s}$	Short exp.	B	0.20	0.05	0.1806	0.1920	0.1174	0.2655
$\rho_{\mu^\pi}$	Price markup	B	0.60	0.20	0.3267	0.3373	0.0917	0.5616
$\rho_{d^{min}}$	Debt to GDP	B	0.60	0.20	0.9978	0.9968	0.9942	0.9995
Std shocks								
$\sigma_r$	MP	IG	0.50	0.50	0.1838	0.1866	0.1670	0.2063
$\sigma_\zeta$	Exp. share	IG	1.00	1.00	3.2871	3.3438	2.9291	3.7683
$\sigma_z$	Tfp	IG	1.00	1.00	1.1350	1.1375	0.9370	1.3409
$\sigma_\tau$	Tax rate	IG	2.00	2.00	0.6972	0.7082	0.6338	0.7820
$\sigma_d$	Demand	IG	10.00	2.00	7.3783	9.4080	7.7047	11.0358
$\sigma_{e^s}$	Short exp.	IG	2.00	2.00	0.4497	0.4634	0.3890	0.5331
$\sigma_{d^{min}}$	Debt to GDP	IG	1.00	1.00	4.4777	4.5513	4.0577	5.0069
$\sigma_\mu$	Price markup	IG	1.00	1.00	0.2956	0.3020	0.2481	0.3572
$\sigma_x$	Investment	IG	10.00	2.00	5.8371	5.9383	5.1902	6.6527



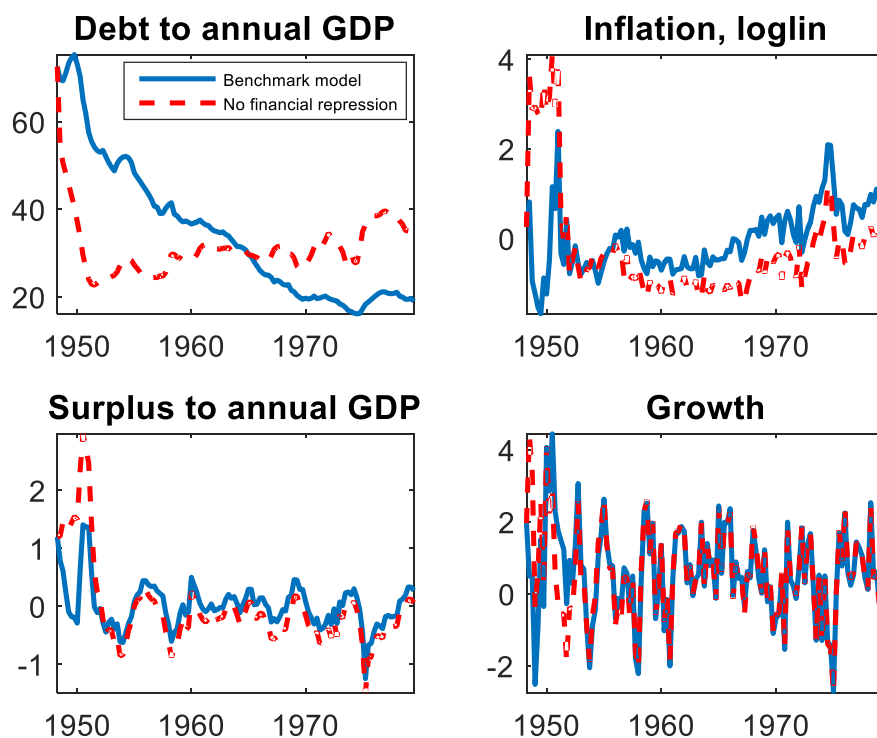
**Figure 4:** Evolution of debt to GDP ratio in the absence of repression without accounting for general equilibrium effects.

the behavior of four selected time series under the counterfactual, contrasting it to the actual outcome.

In order to understand the counterfactual outcome, note that Ricardian equivalence fails in regime F. Because fiscal policy is active (or “non-Ricardian”), government debt held by the private sector raises net worth (it is not necessarily matched by higher taxes in the future). This provides a boost to the private sector which is inflationary and reduces the real value of debt, because monetary policy is accommodative. Real interest rates fall, both short-term and long term. As a result, we find that debt declines more strongly in the absence of financial repression! This result, however, obtains only because our estimates suggest that regime F obtains, once repression is shut off. It is conceivable that in the absence of repression the policy mix would have changed more broadly. We will investigate alternative counterfactuals in future versions of this paper.

## 5 Conclusion

TBC



**Figure 5:** General equilibrium response in a counterfactual economy without repression.

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**Table 2:** Debt reduction accounting, similar to Hall Sargent (2011). Surplus not as important due to updated time series which lowered surplus rate.

Decomposition debt evolution	
Debt in 1948Q2	72.5%
To be completed, overview figures Debt in 1979Q3	19.6%
Change	-52.9%
Nominal return	20.1%
Inflation	-43.9%
Growth	-28.7%
Remeber FOC with financial repression: Deficit / GDP	-0.3%

## A Debt accounting

In order to account for debt dynamics we decompose of the change in the debt to GDP ratio between 1948Q2 and 1979Q3 into nominal return, inflation, growth and deficits. We use the linearized government budget constraint

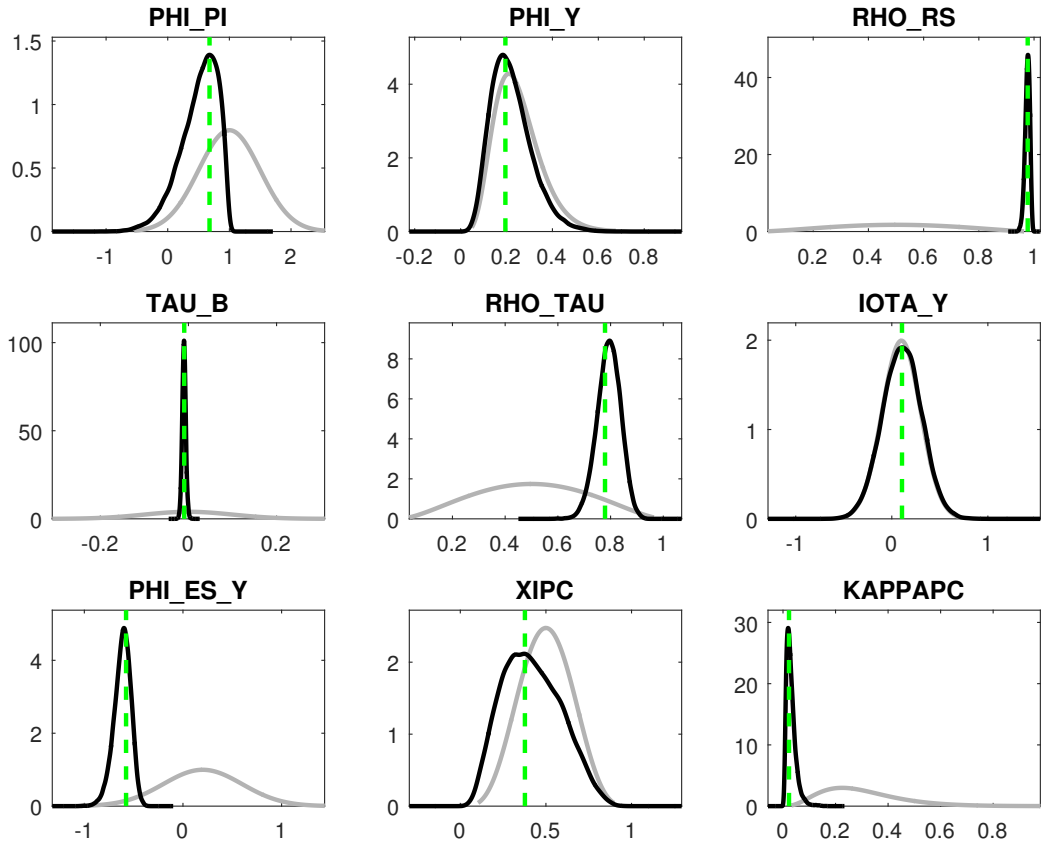
$$\tilde{d}_t = \frac{R^{l,n}}{\Pi e^\gamma} d(\hat{R}_t^{l,n} - \hat{\pi}_t - \hat{y}_t^{growth}) + \frac{R^{l,n}}{\Pi e^\gamma} \tilde{d}_{t-1} - \tilde{s}_t \quad (\text{A.1})$$

with  $\sim$  denoting linear deviations from steady state and  $\hat{\cdot}$  log-deviations,  $d$  the debt to GDP ratio,  $R^{l,n}$  the nominal return on debt,  $\pi$  the inflation rate,  $y^{growth}$  the per-capita growth rate, and  $s$  surplus to GDP ratio. We can re-write the budget constraint in terms of debt to GDP differencens, taking advantage that  $\tilde{d}_{t+1} - \tilde{d}_t = d_{t+1} - d_t$ , with the latter denoting the actual public debt ratios.

$$d_{t+k} - d_{t-1} = \underbrace{\sum_{i=0}^k \frac{R^{l,n} d}{\Pi e^\gamma} \hat{R}_{t+i}^{l,n}}_{\text{nominal return}} - \underbrace{\sum_{i=0}^k \frac{R^{l,n} d}{\Pi e^\gamma} \hat{\pi}_{t+i}}_{\text{inflation}} - \underbrace{\sum_{i=0}^k \frac{R^{l,n} d}{\Pi e^\gamma} \hat{y}_{t+i}^{growth}}_{\text{growth}} - \underbrace{\sum_{i=0}^k \tilde{s}_{t+i}}_{\text{surplus}} + rest_{t-1+i} \quad (\text{A.2})$$

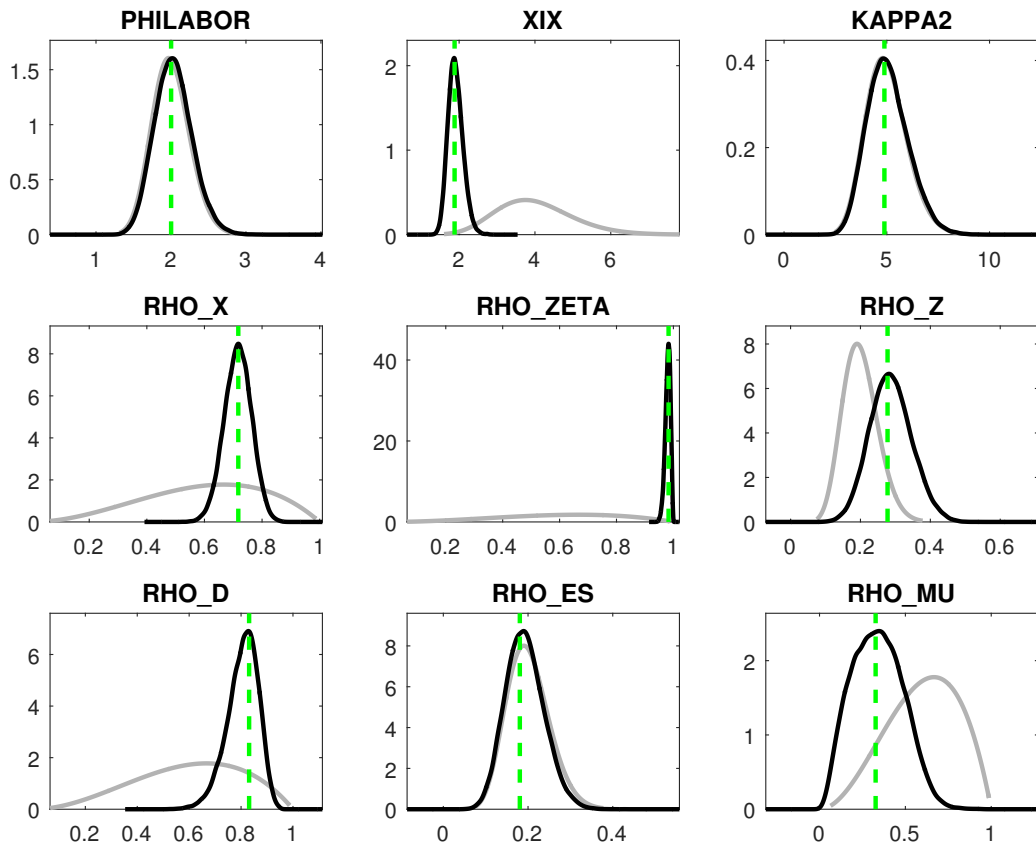
with  $rest_{t-1+i} = \sum_{i=0}^k \left( \frac{R^{l,n}}{\Pi e^\gamma} - 1 \right) \tilde{d}_{t-1+i}$ , which accounts for less than 1% of the reduction. Table 2 depicts the results: The debt-ratio was reduced by roughly 53%-points, most of it was due to inflation and growth, surplus did reduce the ratio especially in the beginning of the sample but the deficits in the late 1970s increased the debt ratio again.<sup>7</sup> Since we put in all components of the government budget constraint as observables, expect the return, the results in table 2 are basically data-driven, the estimation itself does not affect the numbers much. However, what is unobservable, is the return on government debt in the absence of repression.

<sup>7</sup>We add the respective level effects, as for example a log-linear inflation rate of -0.5% is still positive inflation if the steady state of inflation is 1%. Hall Sargent find that surplus did contribute quite significantly to the debt reduction. When inspecting both surplus series we noticed a difference which is not due to different definitions of expenditures and tax revenues but data revision.

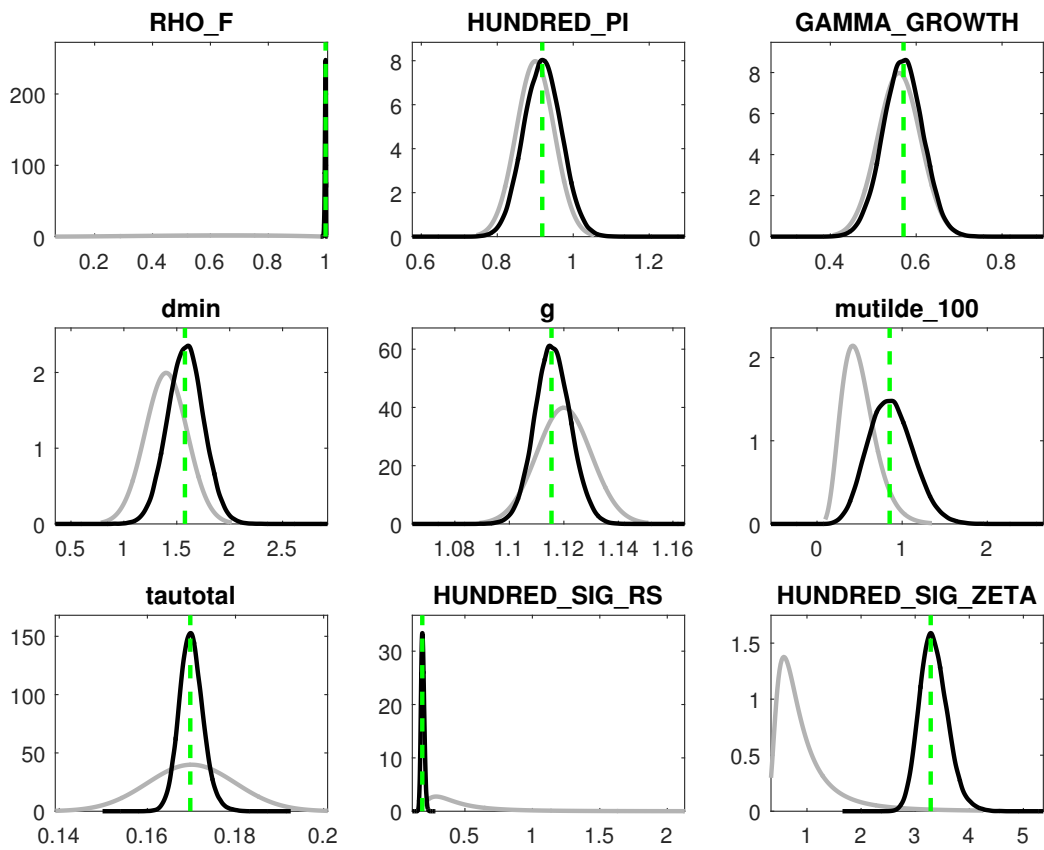


**Figure 6:** Prior (grey) vs. posterior (black) distribution. Green dashed line depicts the mode of the posterior distribution.

## B Additional Figures

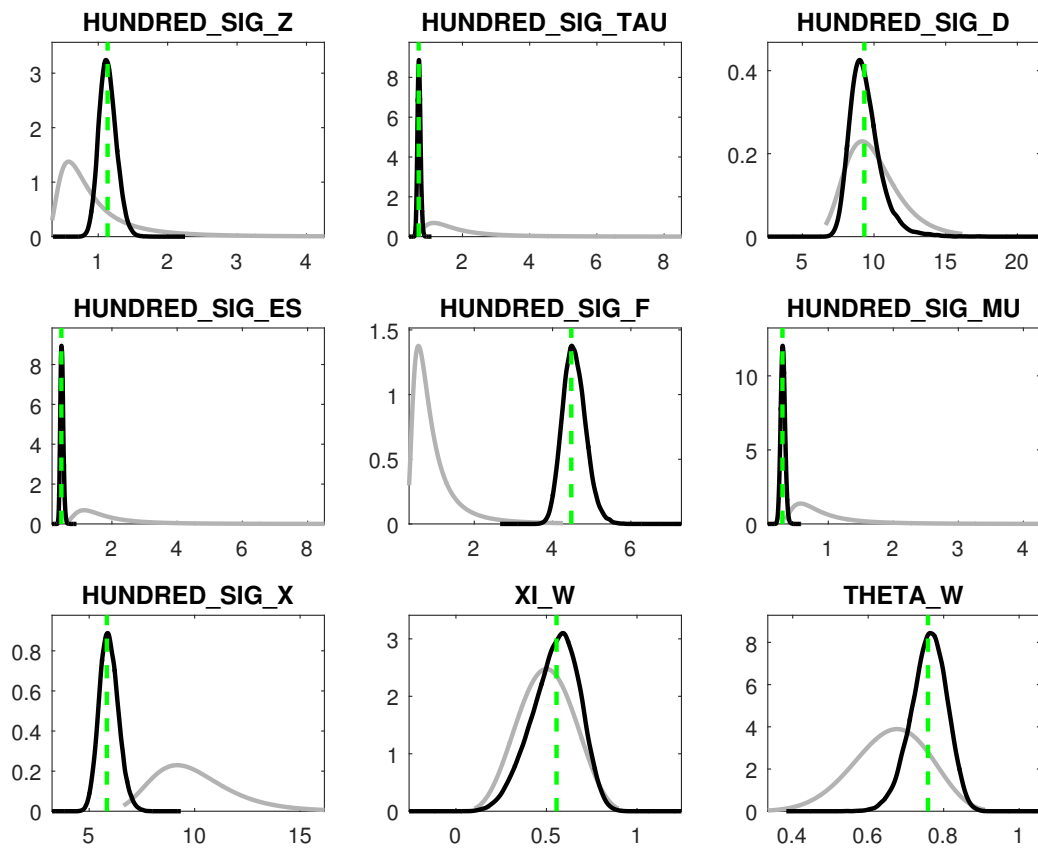


**Figure 7:** Prior (grey) vs. posterior (black) distribution. Green dashed line depicts the mode of the posterior distribution.



**Figure 8:** Prior (grey) vs. posterior (black) distribution. Green dashed line depicts the mode of the posterior distribution.





**Figure 9:** Prior (grey) vs. posterior (black) distribution. Green dashed line depicts the mode of the posterior distribution.

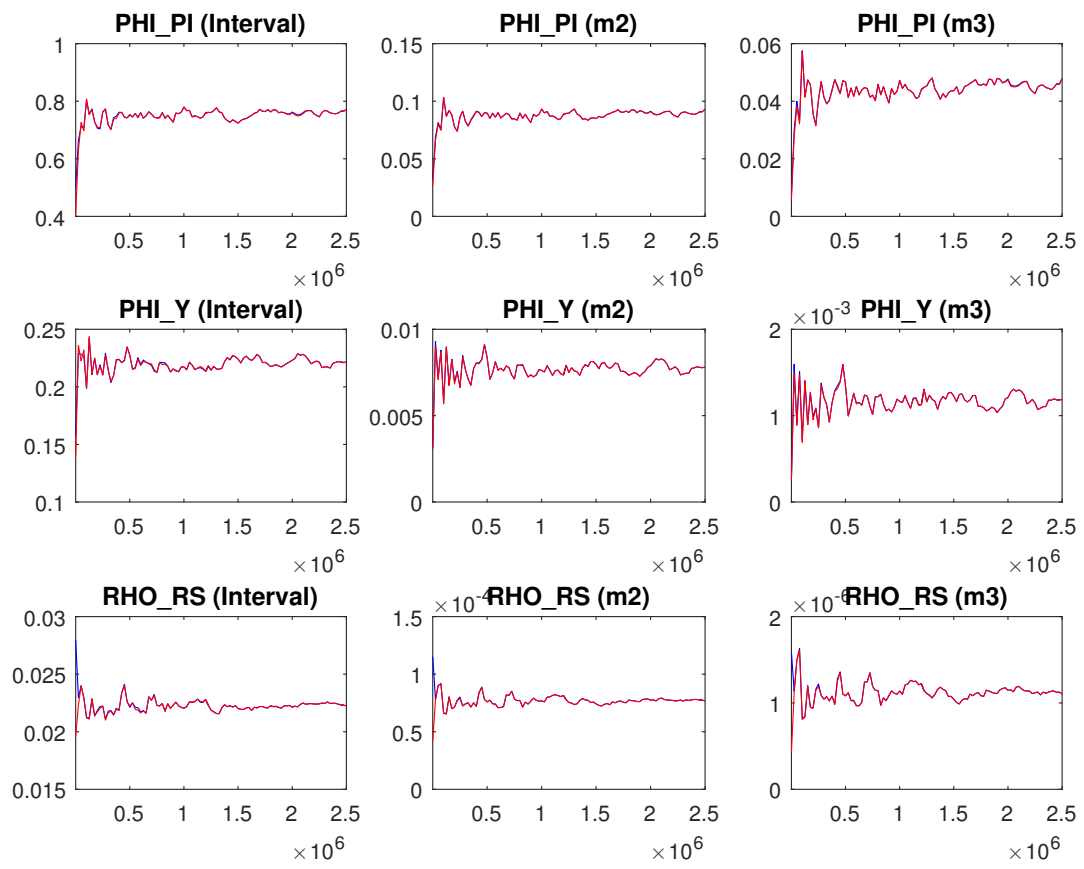


Figure 10: Univariate convergence statistics.

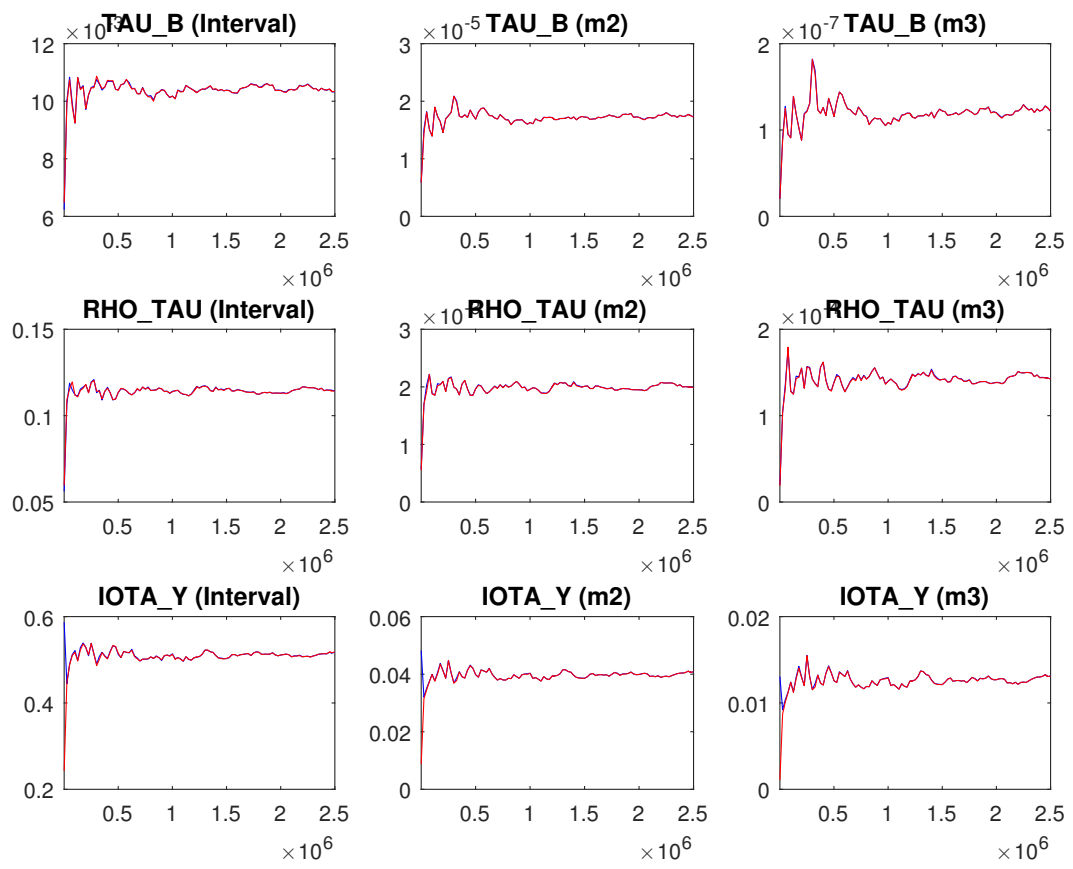


Figure 11: Univariate convergence statistics.

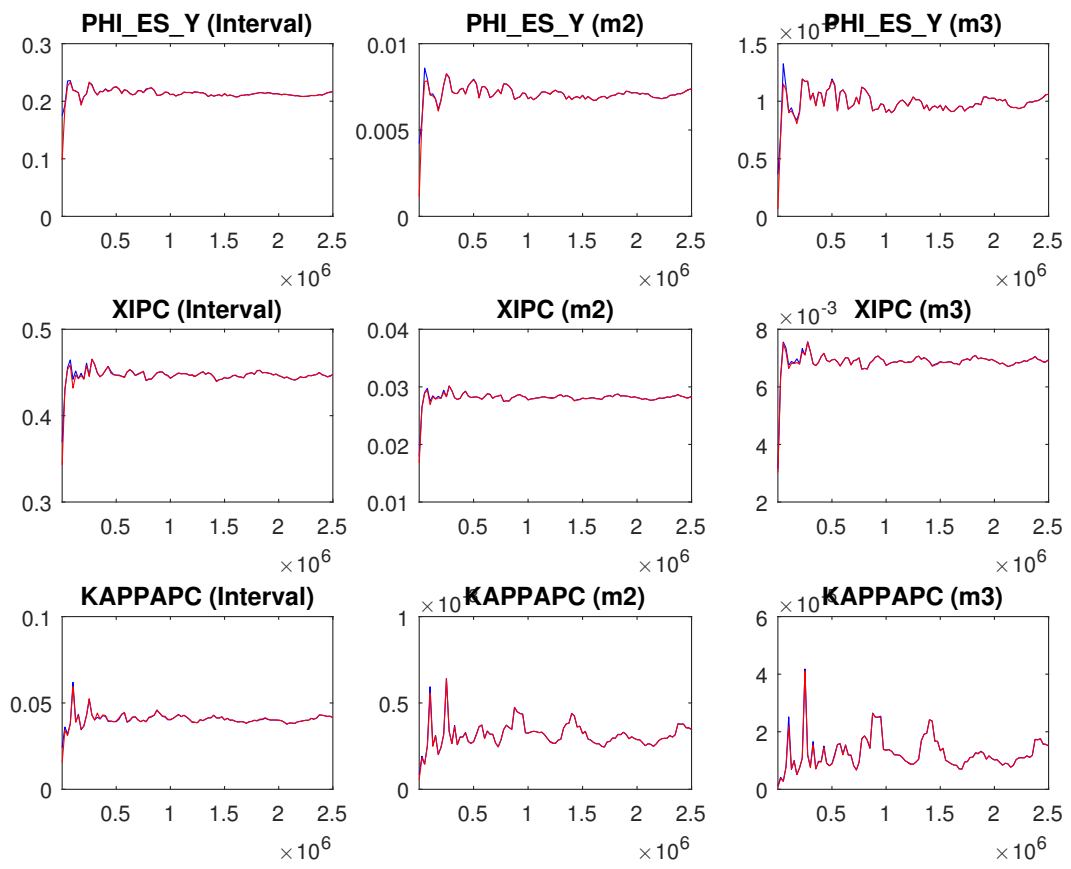
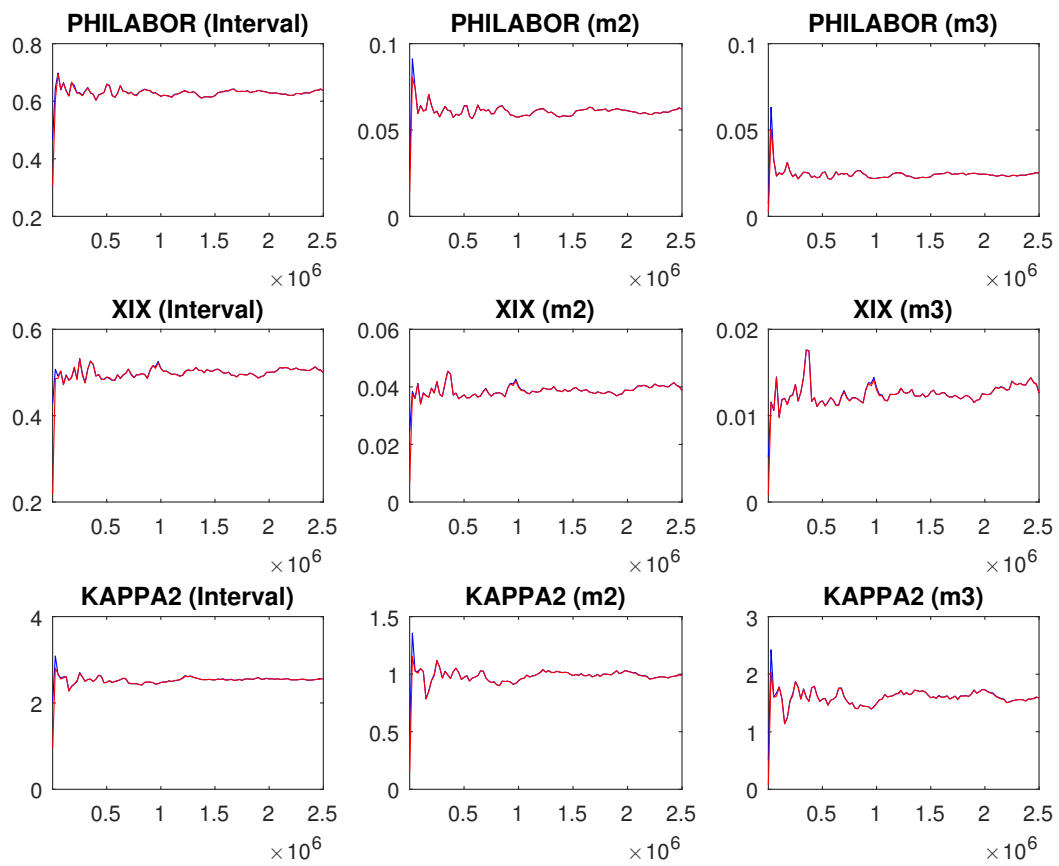


Figure 12: Univariate convergence statistics.



**Figure 13:** Univariate convergence statistics.

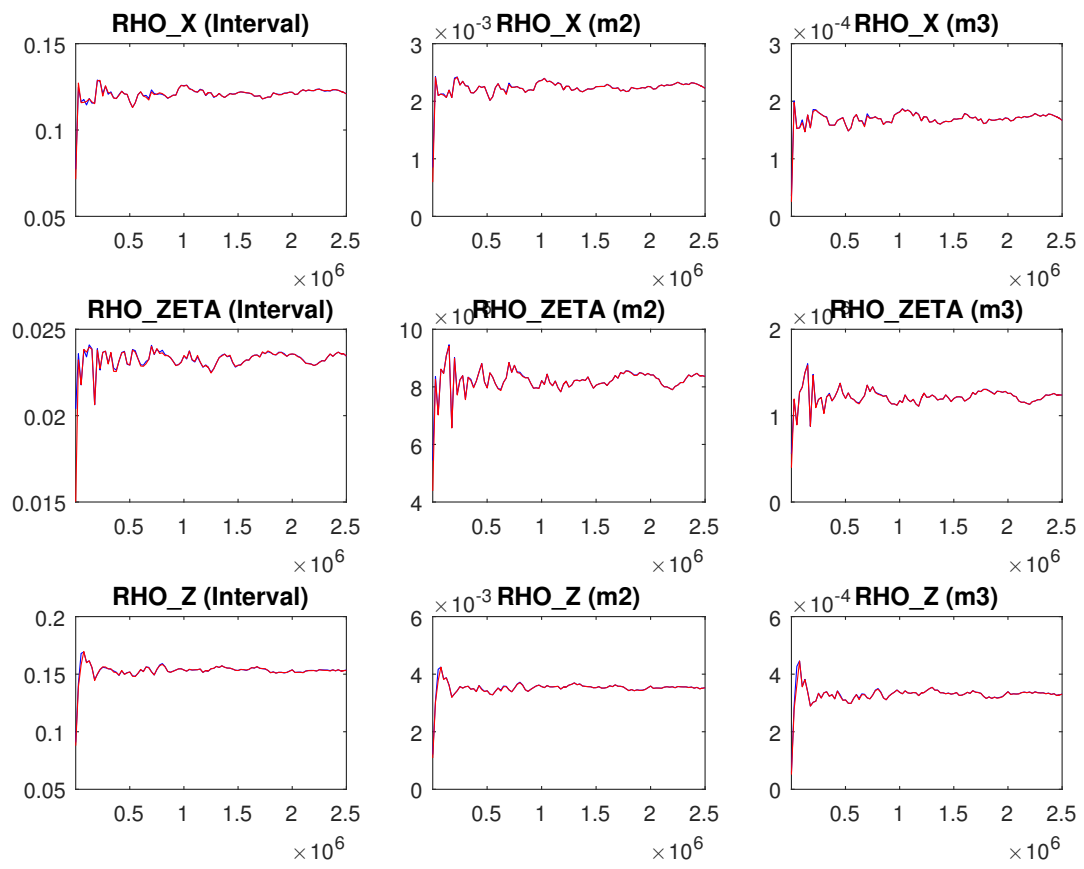
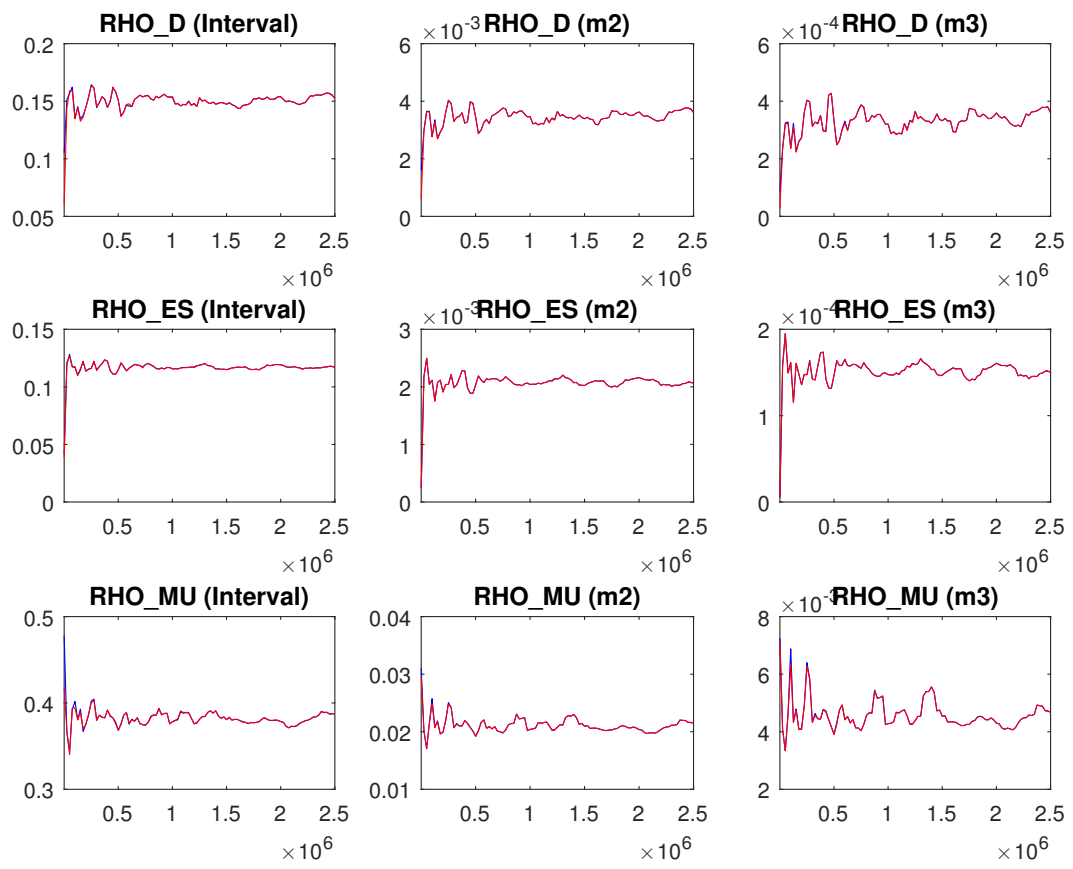
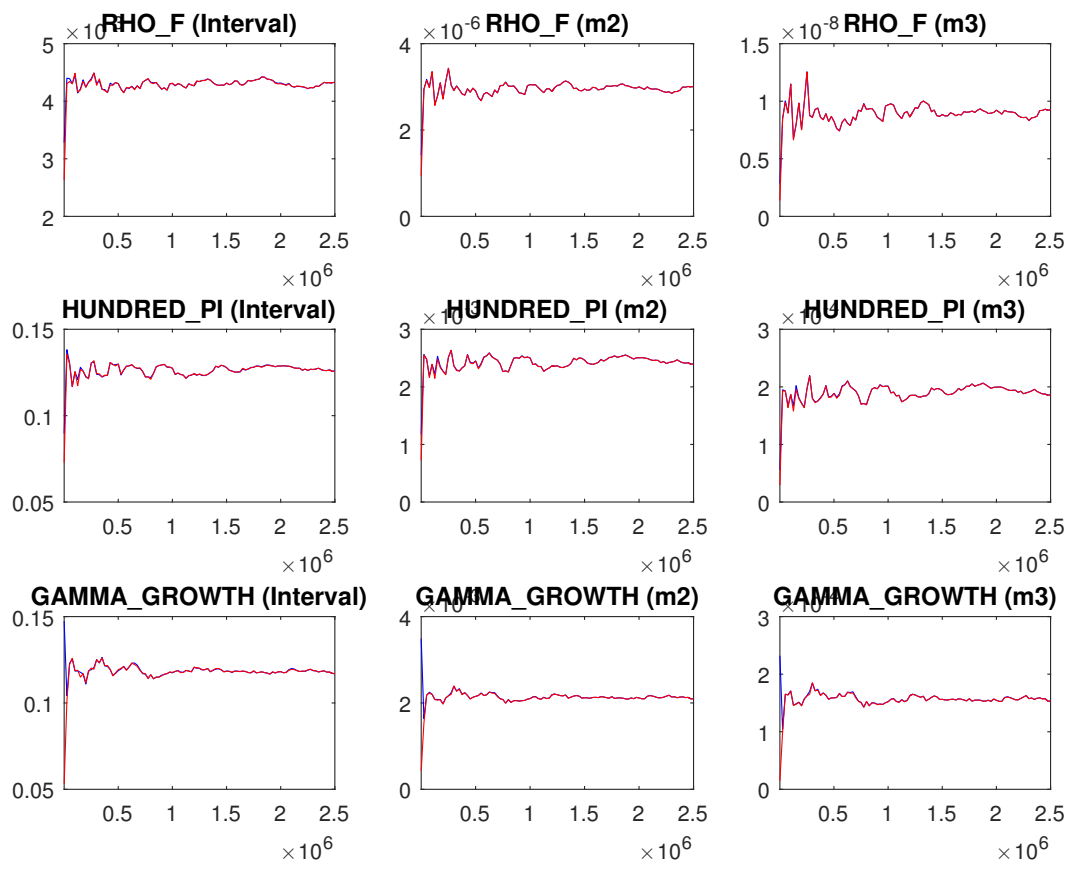


Figure 14: Univariate convergence statistics.



**Figure 15:** Univariate convergence statistics.



**Figure 16:** Univariate convergence statistics.



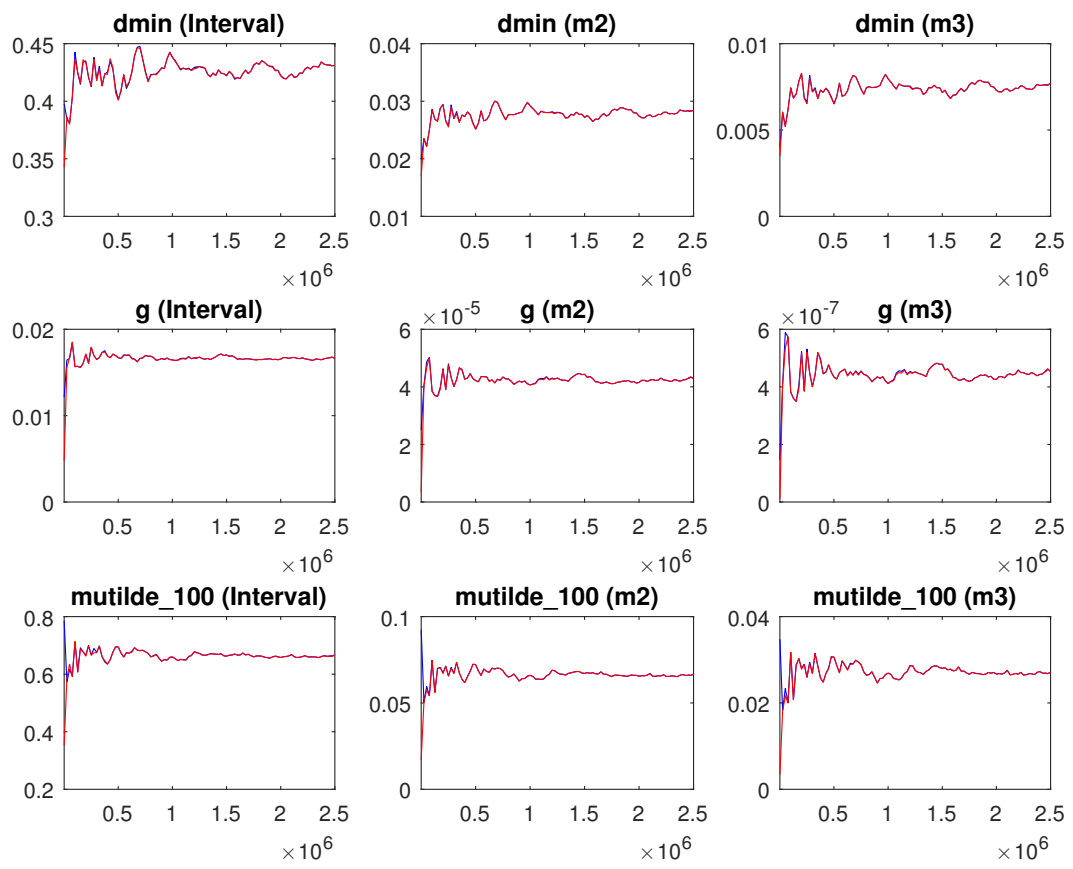


Figure 17: Univariate convergence statistics.

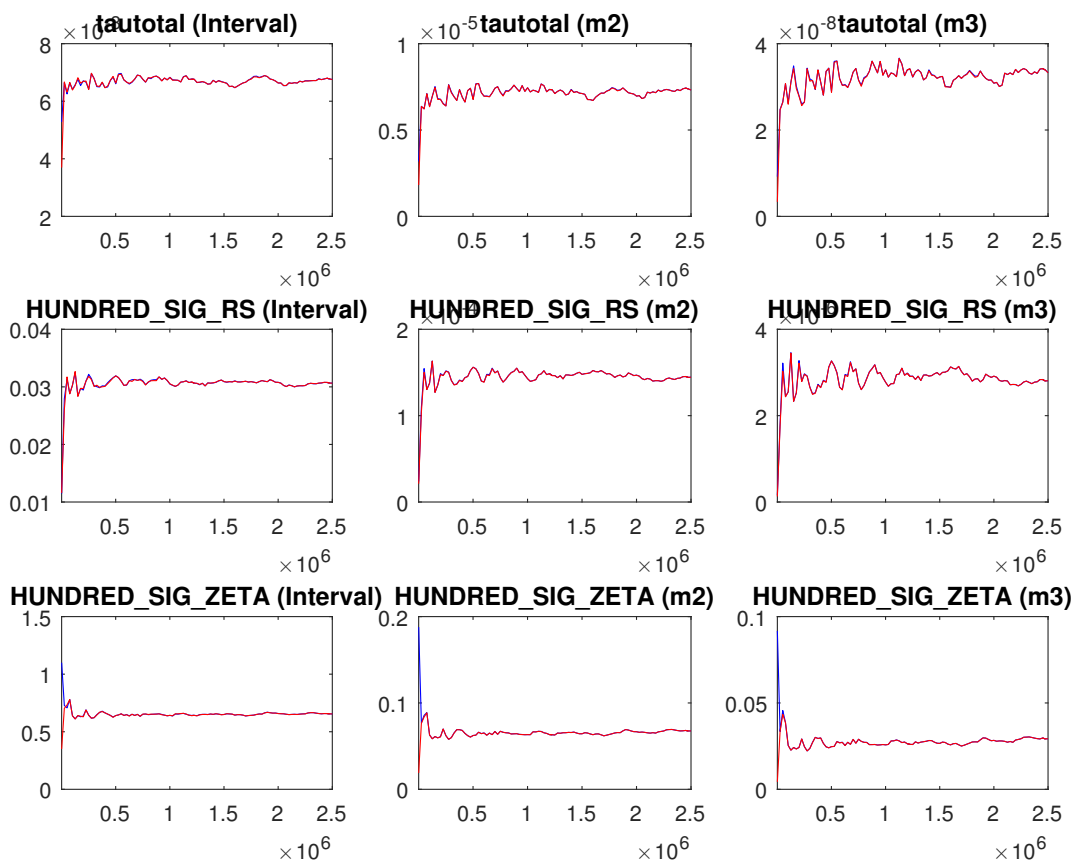
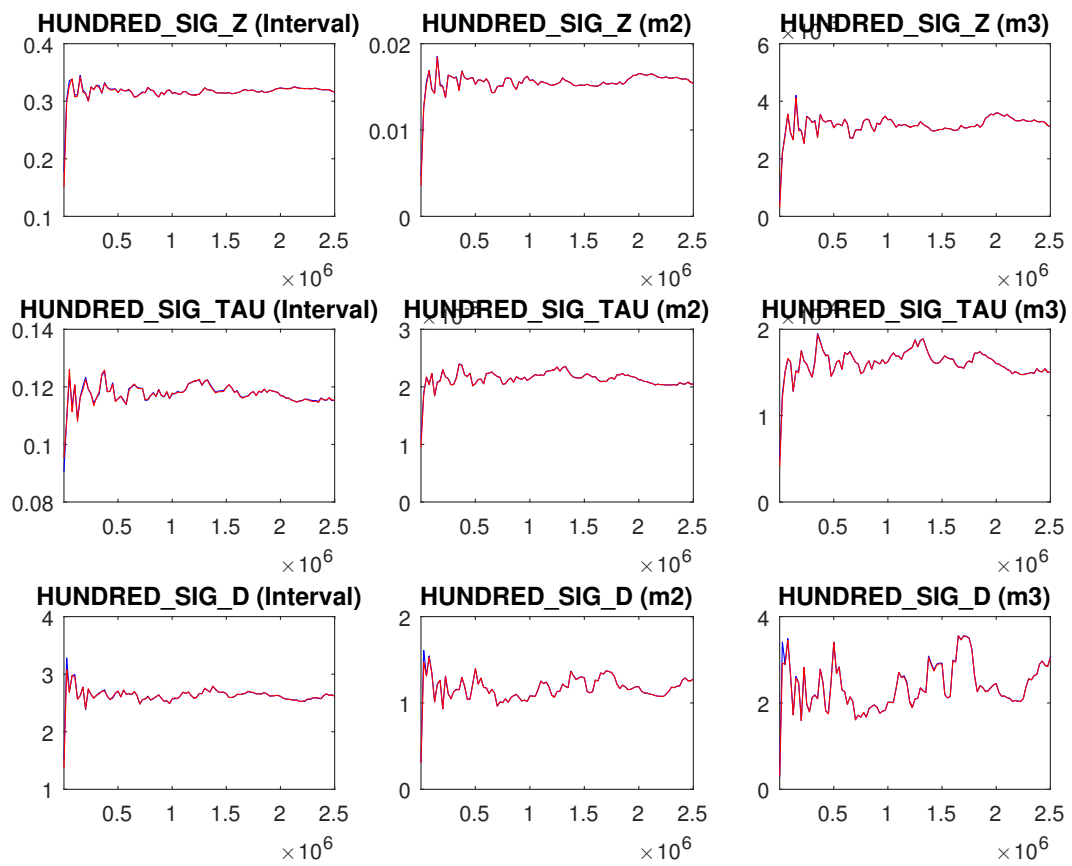
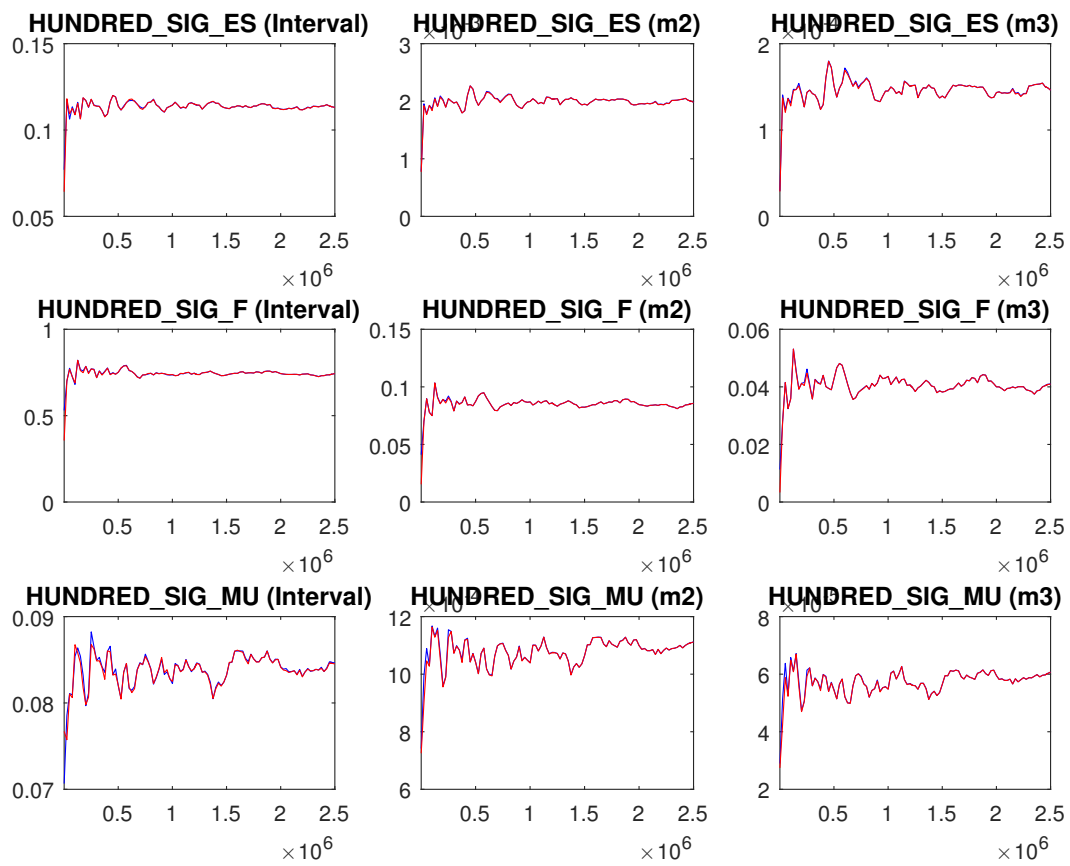


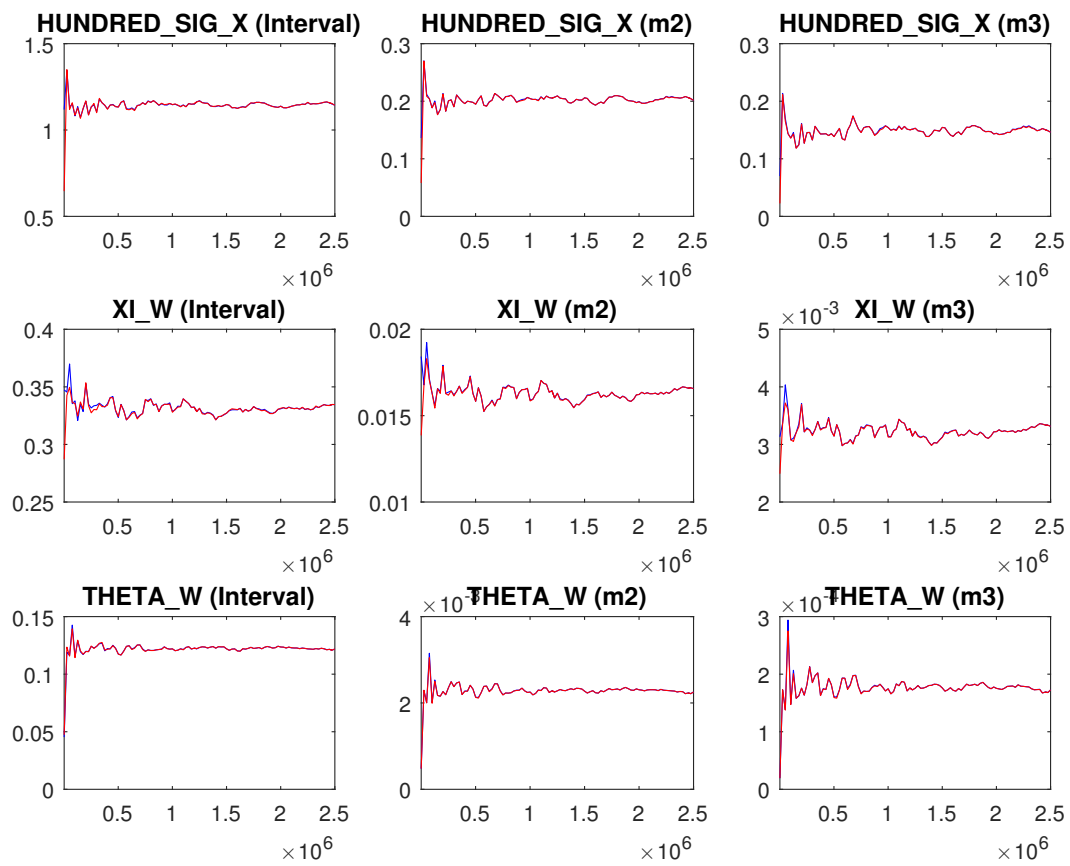
Figure 18: Univariate convergence statistics.



**Figure 19:** Univariate convergence statistics.



**Figure 20:** Univariate convergence statistics.



**Figure 21:** Univariate convergence statistics.