Fiscal-monetary policy interactions in a low interest rate world*

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Abstract

We use a semi-structural model to analyse fiscal-monetary interactions when equilibrium interest rates are very low. The model features conventional monetary policy conducted through the short-term interest rate, central bank balance sheet policies conducted through asset purchases, fiscal policy in the form of a primary deficit rule and government debt accumulation. We show that the systematic use of central bank balance sheet policy considerably enhances macroeconomic stability in a low rate environment as it helps to overcome the ZLB constraint. Our results also suggest that the interactions of fiscal and monetary policy are more pronounced in the presence of the ZLB. The effectiveness of central bank balance sheet policy is enhanced in the presence of countercyclical fiscal policy. At the same time, by protecting against economic slumps and deflation, central bank balance sheet policies also benefit public debt stability.

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1 Introduction

Central bank balance sheet policy has been instrumental to mitigate the constraints posed by the zero lower bound (ZLB) on nominal interest rates over the past decade. In large advanced economies such as the United States, the euro area and Japan, quantitative easing averted deflation and facilitated economic recoveries. The by now pre-eminent importance of balance sheet policies for central banks manifested itself in the wake of the Covid-19 pandemic. All major central banks deployed quantitative easing at a massive scale to provide accommodation as the room for manoeuvre for policy rate cuts was limited.

At the same time, the interaction of fiscal and monetary policy is increasingly moving into the center of the academic and policy debate as the pandemic has reinforced the prevailing low interest rate regime. A key question is whether limited monetary policy space makes the case for a greater role of fiscal stabilisation policy with enhanced coordination of fiscal and monetary policies going forward. Another important question is how central bank balance sheet policy affects fiscal policy and government debt dynamics.

Against this background, we investigate in this paper the effectiveness and interaction of monetary and fiscal policy in maintaining macroeconomic stability under ZLB constraints. While there is a large literature on the optimal and robust conduct of conventional monetary policy, comparable analyses of balance sheet policies in the presence of the ZLB are still missing. Similarly, while there is a large literature on the optimal coordination of fiscal and monetary policy, fiscal-monetary interactions have not been analysed to great extent from the perspective of an increasingly binding ZLB and greater reliance of central banks on balance sheet policies.

Such analysis is essential given that equilibrium real interest rates appear to have declined significantly over the past couple of decades, with the implication that the ZLB will likely be frequently encountered in recessions going forward. Estimates of structural models as well as assessments of central banks themselves suggest that the level of the equilibrium, or natural real interest rate has fallen to near zero levels recently. This is shown in Graph 1 based on the Holston et al. (2017) estimates for the US and the euro area. Therefore, in the 2020s and beyond, the deployment of central bank balance sheet policies can no longer be seen as an unconventional measure.

At the same time, there appears to be a widening gap between potential growth and natural rates, with the former now seemingly exceeding the latter by several percentage points. This is also shown in Graph 1 based on the same source as used above for the natural rate. This observation has important implications for stabilisation policies at the ZLB. Falling natural rates have reduced monetary policy space by increasing the frequency of ZLB events, but at the same time, by falling below trend output growth rates, they would have increased fiscal space. When trend growth is above the natural rate, any level of debt is consistent with a larger primary deficit, meaning larger fiscal space.

Against this background, we develop a small semi-structural model of the economy calibrated to fit historical US and euro area data. The modeling approach follows the semi-structural approach to analysing robust interest rate rules of Orphanides and Williams (2007), extended to account for central bank balance sheet policies, fiscal policy and government debt dynamics. The model features in particular learning-based expectations, allowing for an unanchoring of expectations with potentially destabilising macroeconomic consequences.

We analyse fiscal and monetary policy based on stochastic model simulations and scenario simulations. In the stochastic simulations we simulate model dynamics under a sequence of random structural shocks to demand and supply. The scenario simulations consider a recession scenario comparable to the coronavirus recession many advanced economies are currently experiencing, with unemployment rates rising sharply and persistently.

The analysis devotes particular attention to the interaction of central bank balance sheet policy and public debt dynamics. Specifically, we asses how the activation of balance sheet policy affects the conduct of fiscal policy and government debt dynamics. Likewise, we analyse how the use of fiscal policy influences the conduct and the effects of balance sheet policy. In this vein, we try to capture the unintended side effects of balance sheet policies on the profitability of financial intermediation by monitoring the evolution of term premia as a measure of the returns from maturity transformation.

Our analysis yields the following main findings.

First, a low natural rate of interest implies significant constraints for monetary policy, giving rise to a frequently binding ZLB constraint and worse macroeconomic outcomes with persistent deviations of inflation and unemployment from their steady state levels. Fiscal policy has to intervene more aggressively to compensate for less potent monetary policy, giving rise to higher and more volatility public debt.

Second, the systematic use of countercyclical balance sheet policy by the central bank can overcome the ZLB constraint, yielding more stable inflation and output. It also yields more stable fiscal deficits and public debt levels, as central bank balance sheet policies take some of the burden off fiscal policy. This comes at the cost of frequent and long spells off negative term premia, putting pressure on profits arising to financial intermediaries from maturity transformation and potentially raising risk for financial stability in the longer term.

Third, debt-averse fiscal policy harms economic stability while more aggressive countercyclical fiscal policy in combination with central bank balance sheet policy can enhance it without bringing about more unstable debt trajectories.

Finally, combining moderately negative policy rates as a policy tool with central bank balance sheet policy also appears to improve economic stability, mainly by further containing the rise in public debt during downturns.

The remainder of the paper is organised as follows. Section 2 reviews the relevant literature. Section 3 presents the structure of the model. Section 4 lays out the design of the simulation exercises, including the model calibration, the learning based expectation formation and the set up of the stochastic simulations. In Section 5, we present the simulation results considering different approaches to the conduct of monetary and fiscal policy in a low interest rate environment. We show long-horizon stochastic model simulations and recession scenario simulations. Section 6 concludes.

2 Related literature

TO BE ADDED

3 The model

We develop a semi-structural model following Orphanides and Williams (2007), extended to capture unconventional monetary policy, fiscal policy and government debt. The model features long-term interest rates affecting aggregate demand. Long-term rates are influenced by central bank bond purchases and government debt dynamics through the term premium. The model further features fiscal policy with the primary budget deficit affecting aggregate demand and responding to unemployment through a fiscal policy reaction function. Government debt dynamics are driven by the primary deficit as well as by the dynamics of interest rates, inflation and real output growth.

3.1 Phillips Curve and IS Curve

The Phillips curve takes the standard hybrid form:

$$\pi_t = \phi_\pi \pi_{t-1} + (1 - \phi_\pi) E(\pi_{t+1}) + \alpha_\pi (u_t - u^*) + e_{\pi,t}$$

Inflation (π_t) depends on lagged and expected future inflation as well as on the unemployment rate gap, i.e. the deviation of the unemployment rate from its steady state level ($u_t - u^*$). $e_{\pi,t}$ is an i.i.d. supply shock.

The IS curve is also in standard hybrid form, but features long-term interest rates instead of short-term ones:

$$u_t = \phi_u u_{t-1} + (1 - \phi_u) E(u_{t+1}) + \alpha_u (r_t^l - r^{l*}) + \alpha_f (pb_t - pb^*) + e_{u,t}$$

The unemployment rate is a function its own lag and its expected future value. It depends negatively on the deviation of the long-term real interest rate r_t^l from its equilibrium level r^{l*} and positively on the deviation of the primary fiscal balance ratio pb_t (primary fiscal balance as a ratio of nominal GDP) from its equilibrium debt-stabilising level pb^*. $e_{u,t}$ is an i.i.d. demand shock.

3.2 Long-term interest rates

Long-term interest rates are determined by a standard term structure equation. They reflect the expected future path of short-term rates and the term premium. The nominal short-term rate i_t pins down the real short-term rate $r_t^s = i_t - E(\pi_{t+1})$ and hence the real and nominal (L-period ahead) long-term rate as the average real (nominal) short-term rates plus the term premium tp_t:

$$r_t^l = \frac{1}{L} \sum_{j=0}^{L} r_j^s + tp_t, i_t^l = \frac{1}{L} \sum_{j=0}^{L} i_j + tp_t$$

The equilibrium level of the long-term real interest rate is given by the natural rate of interest r^* plus the equilibrium level of the term premium tp^*:

$$r^{l*} = r^* + tp^*$$

Following term structure models (e.g. Li and Wei (2013)), the term premium is assumed to be a positive function of the amount of public debt in private hands:

$$tp_t = tp^* + \alpha_{tp}(d_{t-1} - d^*) - \alpha_{tp}(b_{t-1} - b^*)$$

where d_{t-1} is the outstanding stock of public debt and b_{t-1} are the public debt holdings by the central bank. d^* and b^* are respectively the steady state level of the government debt and of the central bank government bond holdings (as a ratio to GDP).

Central bank bond holdings and government debt both affect the term premium through the net supply of bonds to the public. Importantly, central bank bond purchases can be effective even if the long-term bond yield has reached its zero lower bound by absorbing government bond issuance arising from fiscal expansion. Moreover, in line with term structure models referred to above, b_{t-1} should be thought of as reflecting the announced bond purchases of the central bank affecting financial markets immediately through a stock effect.

3.3 Monetary policy

Conventional monetary policy is implemented through the short-term nominal interest rate. We assume that the central bank sets nominal short-term rates based on an inertial Taylor rule. There is a zero lower bound preventing the policy rate to take on negative values. The ZLB is captured by defining the policy rate as the maximum of the Taylor rule rate i_t^T plus an i.i.d. monetary policy shock $e_{i,t}$, and zero:

$$i_t = max[i_t^T + e_{i,t}, 0]$$

The Taylor rule rate is given by:

$$i_t^T = \theta_i i_{t-1} + (1 - \theta_i)[r^* + \pi_{t-1} + \theta_\pi(\pi_{t-1} - \pi^*) + \theta_u(u_{t-1} - u^*)]$$

The Taylor rate responds to deviations of inflation from target and of the unemployment rate from its steady state level. There is interest rate smoothing, captured by the autoregressive term i_{t-1}. In steady state, the nominal interest rate is given by the sum of the natural rate r^* and the inflation target π^*.

Unconventional monetary policy takes the form of central bank government bond purchases and is activated only when the policy rate is constrained by the ZLB, i.e. if $i_t^T + e_{i,t}$ is below or equal to zero. When the ZLB binds, the stock of (announced) central bank bond holdings b_t is assumed to respond to economic conditions. The unconventional policy rule for b_t is formulated in the same terms as the conventional monetary policy rule:

$$b_t = \zeta_b b_{t-1} + (1 - \zeta_b)b^* + \zeta_\pi(\pi_{t-1} - \pi^*) + \zeta_u(u_{t-1} - u^*) + e_{b,t}$$

Here ζ_b determines the speed at which asset purchases run off. The reaction coefficients ζ_π and ζ_u represent the amount of purchases (as a share of GDP) the central bank deploys in response to deviations of inflation and unemployment from their starred values. $e_{b,t}$ represents an i.i.d. unconventional monetary policy shock.

The balance sheet reaction function is in terms of the stock rather than the flow. We therefore assume that changes to the stance of central bank balance sheet policy take effect immediately rather than through a sequence of purchases spread over various quarters. That way we aim to capture the stock effect of balance sheet policies that operates through the total expected amount of asset purchase programmes.

If conventional monetary policy is not constrained by the ZLB, the central bank lets announced bond purchases slowly run down:

$$b_t = \zeta_b b_{t-1} + (1 - \zeta_b)b^*$$

3.4 Fiscal policy and government debt dynamics

The fiscal policy rule is expressed in terms of the primary balance as a ratio of GDP. Based on the empirical literature, we assume the fiscal reaction function to take the following form:

$$pb_t = \rho_{pb} pb_{t-1} + (1 - \rho_{pb})pb^* + \psi(u_{t-1} - u^*) + \delta(d_{t-1} - d^*) + e_{pb,t}$$

Fiscal policy aims to stabilise the business cycle (Taylor (2000)) as well as the public debt (Bohn (1998)). Specifically, the primary balance decreases when unemployment rises above its steady state level as the government provides fiscal stimulus. At the same time, the primary balance increases when debt is above its steady state level, reflecting debt stabilisation motives. $e_{pb,t}$ is an i.i.d. fiscal policy shock.

The quarterly dynamics of the public debt-to-GDP ratio are given by:

$$d_t = (1 + i^d_{q,t} - g_{q,t} - \pi_{q,t})d_{t-1} - pb_t$$

where $i^d_{q,t}$ is the quarterly fraction of the annual debt service cost of the government $i^d_{q,t} = i^d_t/400$. $\pi_{q,t}$ is the quarterly fraction of the annualised inflation rate $\pi_{q,t} = \pi_t/400$ as determined by the Phillips Curve. $g_{q,t}$ is the quarterly fraction of the annualised growth rate of real GDP $g_{q,t} = g_t/400$. g_t is in turn determined through the IS curve in combination with Okun's law $g_t = g^* - 2(u_t - u_{t-1})$ where g^* is steady state real GDP growth.

The debt-stabilising steady state quarterly primary balance is given by:

$$pb^* = (r^*_q + tp^*_q - g^*_q)d^*$$

where respectively $r^*_q = r^*/400$, $tp^*_q = tp^*/400$, $g^*_q = g^*/400$ and $pi^*_q = pi^*/400$.

4 Simulation design

4.1 Model calibration

The calibration of the model parameters is informed by the previous literature and empirical evidence. We calibrate the backward-lookingness of the PC and IS equations to $\phi_\pi = \phi_u = 0.5$ in line with Orphanides and Williams (2007). The slope of the Phillips Curve is set at $\alpha_\pi = 0.1$, thus assuming a relatively flat Phillips Curves in line with recent evidence. The elasticity of the unemployment rate to the long-term real interest rate in the IS curve is calibrated as $\alpha_u = 0.15$. This calibration is based on the estimated interest rate elasticity with respect to the short rate of about 0.035 in Orphanides and Williams (2007) and an impact of a 100bp shock to the policy rate on the 5-year bond yield of 22.5bps. We set the fiscal multiplier at $\alpha_f = -0.5$, which corresponds to an output multiplier of 1.

The steady-state variables are fixed at $r^* = 0.5$, $u^* = 4$, $\pi^* = 2$, $g^* = 1.5$ and $tp^* = 1$, which implies $pb^* = 0$. In the simulations, we also consider a higher value of r^* of 2.5, representing the pre-GFC period. We further set $d^* = 1$ and $b^* = 0.1$, implying steady state levels of government debt and of the central bank balance sheet of 100% of GDP and 10% of GDP, respectively.

We assume that the average maturity of government debt is 5-years. The long-term interest rate is therefore a 5-year bond yield so that $L = 20$. In the term premium equation, α_{tp} is calibrated to -0.05. This implies that central bank bond purchases of the scale of 1% of GDP reduce the term premium by 5bps, in line with the empirical estimates of Li and Wei (2013).

We calibrate the parameters in the Taylor rule at $\theta_i = 0.85$, $\theta_\pi = 0.5$ and $\theta_u = -2$. This is the inertial version of the Taylor (1999) rule, with the response coefficient to the unemployment gap obtained by applying Okun's law.

The central bank balance sheet reaction function is calibrated as follows. The parameter ζ_b which determines the speed at which bond holdings run off the balance sheet is calibrated to 0.95. This implies a half-life of the balance sheet of about 3.5 years, so that the central bank on average does not sell bonds over the business cycle. Return of the balance sheet to steady state is instead brought about by maturing bonds passively running off the balance sheet. This assumption is in line with the way central banks have approached balance sheet policy normalisation in practice.

The balance sheet policy reaction coefficients ζ_π and ζ_u are set -6.75 and 9, respectively. The balance sheet reaction coefficients are calibrated in a way that is consistent with the Taylor (1999) rule, the impact of a change in the short-term rate on long-term according to the term structure equation and the calibrated impact of balance sheet measures on the term premium. So it is essentially the Taylor (1999) rule operated through the central bank balance sheet.

In the fiscal rule, we set $\rho_{pb} = 0.7$, $\psi = -0.25$ and $\delta = 0.01$. This calibration is based on the empirical literature estimating fiscal policy reaction functions. Finally, the debt service cost of the government i_t^d is approximated by the average of the 5-year bond yield over the past 20 quarters.

4.2 Expectations formation

The baseline model is validated under RE, but in the simulation exercise, we allow agents to deviate from model-consistent expectations. We allow for two forms of deviation. In the first one, agents are equipped with the VAR representation of the RE at the beginning of the simulation, but as soon as observations on unemployment, inflation and short-term rates become available, they update the VAR coefficients using a constant-gain learning ($\kappa = 0.02$). This calibration of the gain parameter corresponds to the baseline case in Orphanides and Williams (2007).

More formally, agents observe $Y_t = [u_t, \pi_t, i_t]$ and model the observed variables as a VAR(1):

$$Y_t = c + AY_{t-1} + e_t;$$

forecasts for the variables in $t+1$ are produced based on this representation[1] and are then plugged in the model equations to generate a dynamics that potentially deviates from RE.

At the beginning of the simulation, agents are equipped with the coefficients of the VAR representation of the RE solution of the model, $c^{(0)}$ and $A^{(0)}$. As new observations become available, the learning process starts and the coefficient matrices are updated. This implies that not only the short-run dynamics of the expectations differ from the RE solution, but also that long-term expectations can drift away from the steady state variables.

4.3 Stochastic simulation setup

We simulate the model under a random sequence of demand shocks $e_{u,t}$ and supply shocks $e_{\pi,t}$, while setting all policy shocks to zero. The standard deviations of the demand and supply shocks are respectively set as $\sigma_{e_{u,t}} = 0.45$ and $\sigma_{e_{\pi,t}} = 0.75$.[2] The simulation exercise is based on generating times series of size 200 (50 yeas) from the equations of the model, discard the first 100 observations as burn-in and repeat the simulation 500 times (we then end up with 500 replications of time series of size 200 observations each).

Private agents' learning process injects a nonlinear structure into the model that may generate explosive behavior in a stochastic simulation of sufficient length for some policy rules that would do a good job of stabilising the economy under RE. One possible cause of such explosive behavior is that the forecasting model itself may become explosive. We take the view that in practice private forecasters reject explosive models. We implement this by computing, in each period of the simulation, the maximum root of the forecasting VAR excluding the constants. If this root falls below the critical value of 0.995, the forecast model is updated as

[1] The expected long-term real rate is actually produced through L-periods ahead forecasts of short-term rates and inflation in the VAR, to preserve the no-arbitrage link between short- and long-term rates.

[2] These standard deviations obtain when estimating empirical IS and Phillips curves as in Orphanides and Williams (2007) over the sample period 1990Q1-2016Q4.

described above; if not, we assume that the forecast model is not updated and the matrices C and R are held at their respective previous period values.

This constraint on the forecasting model is insufficient to assure that the model economy does not exhibit explosive behavior in all simulations. For this reason, and following Orphanides and Williams (2007), we impose a second condition that restrains explosive behavior. In particular, if the inflation rate, nominal interest rate, or unemployment gap exceed in absolute value six times their respective unconditional standard deviations (computed under the assumption of RE and known and constant natural rates), then the variables that exceed these bounds are constrained to equal their corresponding limit in that period. We further add a threshold of 1000% on the debt ratio in order to rule out excessively explosive debt trajectories. These constraints on the model are sufficient to avoid explosive behavior for the exercises that we consider in this paper and are rarely invoked for most of the policy rules we study.

5 Simulation results

We report two sets of results from the simulations. The first is for the full stochastic simulation of the model. We report the Monte Carlo means and standard deviations of the key model variables. Specifically, in each simulation we compute the averages of the unemployment rate, the inflation rate, the short- and the long-term interest rates as well as the end-of-simulation levels of government debt and of the central bank balance sheet. We also compute how many times the ZLB is binding and how often the term premium has been negative as a rough gauge of the cost of implementing central bank balance sheet policy. The second set of results is from a scenario analysis where we simulate a severe recession, comparable to the coronavirus recession.

5.1 Long-horizon simulations

We first assess the longer run consequence of a low level of the natural rate of interest. To this end, we simulate the model once with $r^* = 2.5$, representing the pre-GFC regime, and once with $r^* = 0.5$ representing the new post-GFC regime according to consensus estimates. Moreover, we assume that the central bank does not use balance sheet policy in order to isolate the constraining effect of a lower r^* on conventional monetary policy conducted through policy rates.

The results reported in Table 1 suggest that a lower level of the natural rate of interest constrains monetary policy over longer horizons in a significant way. The number of instances policy rates hit the ZLB essentially doubles from 10% to 20%. The more often binding constraint on conventional monetary policy is reflected in higher average realisations of the unemployment rate, lower inflation and higher government debt. As a result, the economy on average deviates in notable ways from its steady state. Table 1 also reports results from model simulations where there is no ZLB on policy rates. These simulations confirm that in the absence of the ZLB constraint, the economy would not persistently diverge from its steady state. It also gives a first hint of the potential benefit of setting policy rate to negative values, a point we will come back to.

We next assess the stabilising role of central bank balance sheet policy over longer horizons. In this vein, we simulate the model under the baseline calibration with $r^* = 0.5$ and compare it with the model considered above where there is no central bank balance sheet policy. The results reported in Table 2 show that the activation of balance sheet policy has economically significant stabilising effects over long horizons. The unemployment rate, inflation and also public debt average at the their steady state values across simulations.

At the same time, reflecting the additional degree of freedom for monetary policy provided by the balance sheet tool and the associated greater macroeconomic stability, the ZLB is on average less often binding. The number of times policy rates hit zero more than halves to 9%. However, these benefits of an active use of balance sheet policy by the central bank do not come free of charge. The last column of Table 2 shows that in almost 30% of the simulation periods, term premia are compressed to negative levels as a consequence of central bank balance sheet policy. This implies pressure on financial intermediaries whose profits accrue from maturity transformation. This could give rise to financial stability risks not captured in our model.

The simulations further show that another consequence of a monetary policy that does not resort to balance sheet policies is a high frequency of high debt and low inflation outcomes over longer horizons (Figure 2, left-hand panel). By contrast, under the baseline calibration with active central bank balance sheet policy, the number of such debt deflation outcomes is significantly reduced (right-hand panel).

We next explore how different approaches to fiscal policy and monetary policy affect economic performance in the face of a low r^*. First, we consider the case of a more debt averse fiscal authority that aims to bring debt back to its steady state or target level in a faster way than assumed under our baseline calibration. Specifically, we assume a fiscal rule that responds more strongly to the deviation of debt from its steady state level by setting $\delta = 0.04$ which is four times the level under the baseline calibration. The simulation results, reported in Table 3, show that such a policy has detrimental economic consequences. The ZLB is more often binding, requiring more active central bank balance sheet policy as reflected in a larger central bank balance sheet on average. Still, average unemployment rates are higher and inflation rates lower than under the baseline fiscal rule.

The debt-averse fiscal policy even turns out to be self-defeating as the debt ratio averages 2 percentage points above its steady state level across the simulations. That said, debt-averse fiscal policy manages to avoid very high debt outcomes, but at the cost of a larger number of simulations with deflation compared to the baseline fiscal rule (Figure 3). This is also reflected in a markedly thicker left tail in the distribution of inflation outcomes across simulations under the debt-averse fiscal rule compared to the baseline calibration (Figure 4).

Second, we consider a fiscal policy rule that provides extra fiscal accommodation when policy rates are stuck at the ZLB. The extra-accommodative fiscal rule takes the following form:

$$pb_t = \rho_{pb} pb_{t-1} + (1 - \rho_{pb}) pb^* + \psi(u_{t-1} - u^*) + \delta(d_{t-1} - d^*) + \Psi_{ZLB}(i_t - i_t^T) + \epsilon_{pb,t}.$$

The additional term $\Psi_{ZLB}(i_t - i_t^T)$ means that fiscal policy provides additional accommodation proportional to the extent to which policy rates are constrained by the ZLB, captured by the deviation between actual policy rates and the target policy rate according to the Taylor rule. In the simulations, we set $\Psi_{ZLB} = 0.5$, implying that for each percentage point shortfall in monetary accommodation due to the ZLB, the fiscal authority increases the primary deficit by 0.5 percentage points of GDP.

The simulation results suggest that such extra accommodative fiscal policy at the ZLB significantly reduces the number of simulations that end in debt deflation (Figure 5, left-hand panel). Strikingly, while the fiscal rule implies on average more expansionary fiscal policy, it results in more stable public debt as a result of greater macroeconomic stability. However, this outcome depends crucially on central bank balance sheet policy being active. Without central bank balance sheet policy, extra accommodative fiscal policy results in a larger number of debt deflation outcomes (Figure 5, right-hand panel).

Finally, we also consider the possibility of breaking through the ZLB and lower policy rates to moderately negative levels in case of need, as many central banks have done over the past years. Specifically, we consider the case where policy rates are not constrained by the ZLB but by an ELB of -0.5%.

Simulating the model under this moderately negative ELB and keeping all else at baseline suggests that negative rates can also help to improve macroeconomic and debt stability in a low interest rate environment. Similar to the case of extra accommodative fiscal policy considered before, the introduction of a negative ELB considerably reduces the number of deb deflation outcomes in our simulations (Figure 6). Negative rates are however no substitute for central bank balance sheet policy in a low rate regime. A negative ELB alone without central bank balance sheet policy still yields a large number of debt deflation outcomes (Figure 6, right-hand panel).

5.2 Scenario analysis

The scenario analysis is designed as a controlled sequence of shocks to the IS curve (instead of the random shocks used in the simulations). It is also based on simulated trajectories, each one starting from the last simulated value in the simulation exercise. By doing so, the starting point of the IRFs can be thought of as drawn randomly from the steady-state distribution of the model.[3]

The "severe recession" is implemented as a shock of size 6 to the IS curve, that is, an increase in the unemployment rate of 6 percentage points (bringing the unemployment rate to 10%). The shock is further assumed to be highly persistent, with an AR coefficient of 0.9.

In order to flesh out the stabilising role of central bank balance sheet policy in such a scenario, we compare, as a first exercise, the model dynamics of the baseline model and a model where the central bank only uses conventional monetary policy and does not activate countercyclical bond purchases. The results reported in Figure 7 show that bond purchases significantly benefit macroeconomic stability in a deep recession. The unemployment rate and the inflation rate recover much faster when balance sheet policy is activated (blue lines) compared to a situation where the central bank does not deploy its balance sheet tool (red lines). The

[3]Importantly, this also includes agents' expectations based on what they learned during the simulation exercise.

charts further reveal that bond purchases also provide relief for fiscal policy. As monetary policy now takes on a greater role in stabilising the economy, fiscal policy can afford to do less, reflected in lower fiscal deficits and a flatter trajectory of the public debt. Central bank balance sheet policy hence also benefits fiscal stability when a major recession hits.

We next consider the case of debt-averse fiscal policy, as before modelled through a quadrupling of the response of the primary deficit to the deviation of debt from steady state. The simulation results reported in Figure 8 show that such a policy is highly counter-productive also in a recession scenario. The consequence is less fiscal stimulus, reflected in much higher unemployment and much lower inflation (red lines) compared to baseline (blue lines).

Next, we also simulate the recession scenario under the fiscal policy rule that provides extra fiscal accommodation when policy rates are stuck at the ZLB. Figure 9 shows that such a policy approach can be highly beneficial under a severe recession scenario. Unemployment and inflation rates recover considerably faster (red lines) than under the baseline calibration (blue lines). At the same time, while such a policy delivers higher primary deficits, it does not result in a higher debt ratio due to the faster economic recovery.

Finally, we simulate the recession with an ELB of -0.5% as opposed to the baseline ZLB. The simulations reported in Figure 10 suggest that the benefits in terms of recovery speed are moderate. An additional 50bps room for policy rate cuts does not seem to enhance the stabilising capacity of conventional monetary policy in a major way. However, negative rates, by delivering lower interest rates and a slightly faster economic recovery, yield a considerably smaller increase in public debt in a major recession, thus benefiting future fiscal sustainability.

6 Conclusions

The analysis of this paper establishes four main results.

First, in a world where r^* is very low, the ZLB represents a major constraint for conventional monetary policy conducted through the setting of policy rates. The economy can diverge from its steady state and there is a significant risk of debt deflation.

Second, central bank balance sheet policy, specifically large-scale purchases of government bonds, can considerably improve macroeconomic stability in a low interest rate world. It further significantly enhances the stability of the public debt without explicitly aiming to do so.

Third, the design of fiscal rules matters. Excessively debt averse fiscal rules are counterproductive in a low r^* world. By contrast, extra accommodative fiscal policy in case of a binding ZLB constraint in combination with central bank balance sheet policy enhances both economic and fiscal stability.

Finally, combining moderately negative rates as a policy tool with central bank balance sheet policy can also enhance stability, mainly by further containing the rise in public debt during downturns.

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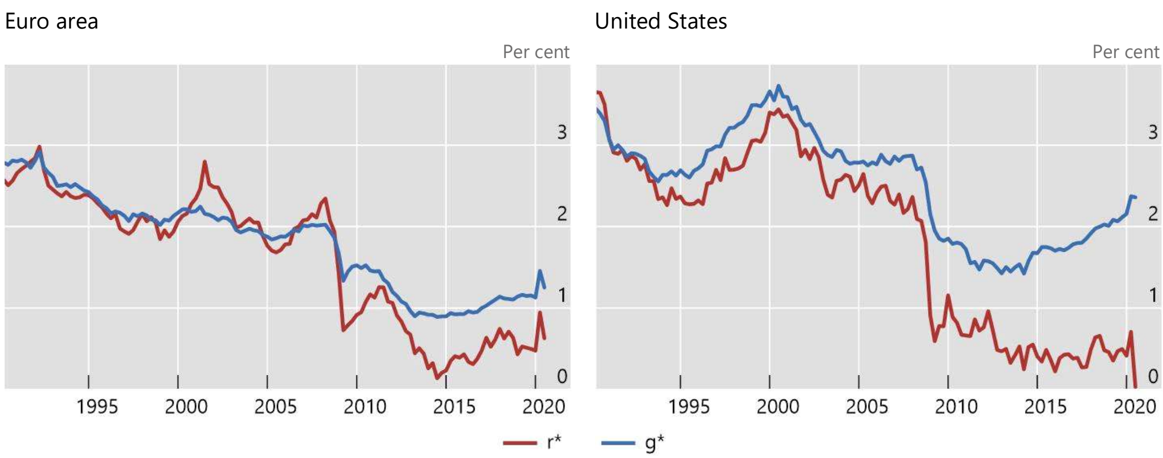
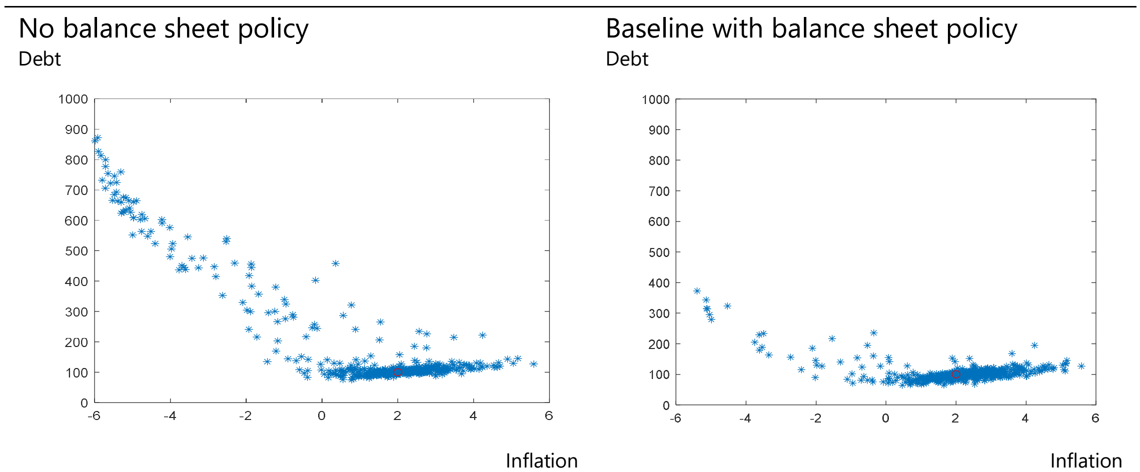
Figures

Figure 1: Natural rates and trend growth



Source: Holston et al. (2017).

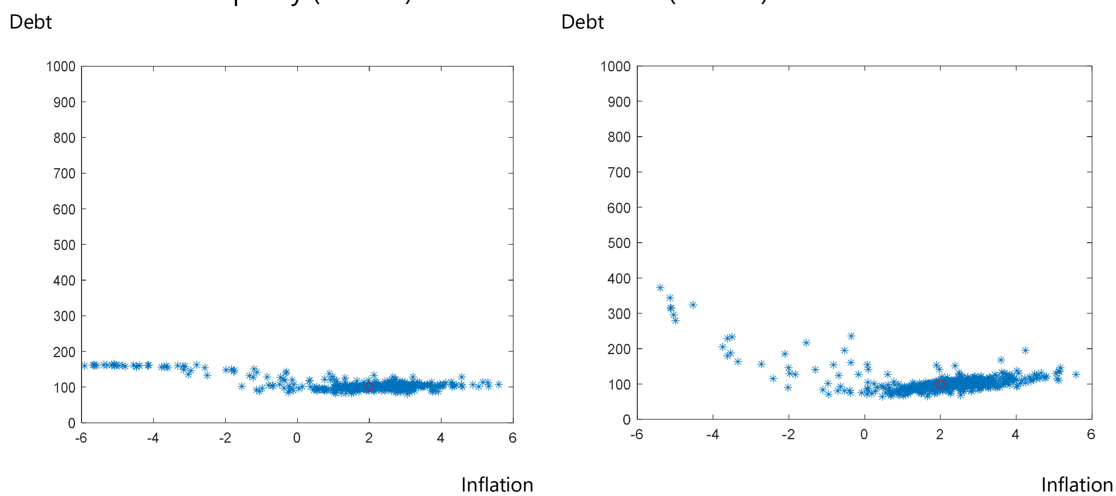
Figure 2: Debt and inflation with and without central bank balance sheet policy



Average realisations over long-horizon simulations

Figure 3: Debt and inflation with debt-averse fiscal policy vs baseline

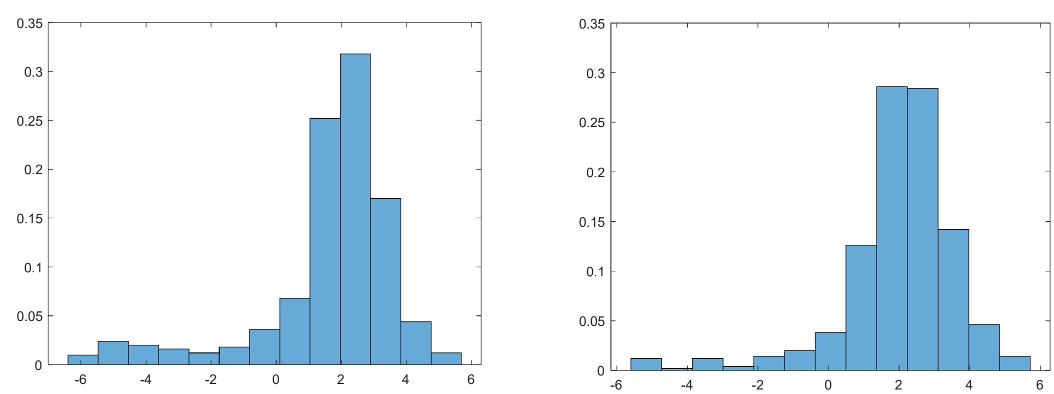
Debt-averse fiscal policy (δ=0.04) | Baseline (δ=0.01)



Average realisations over long-horizon simulations

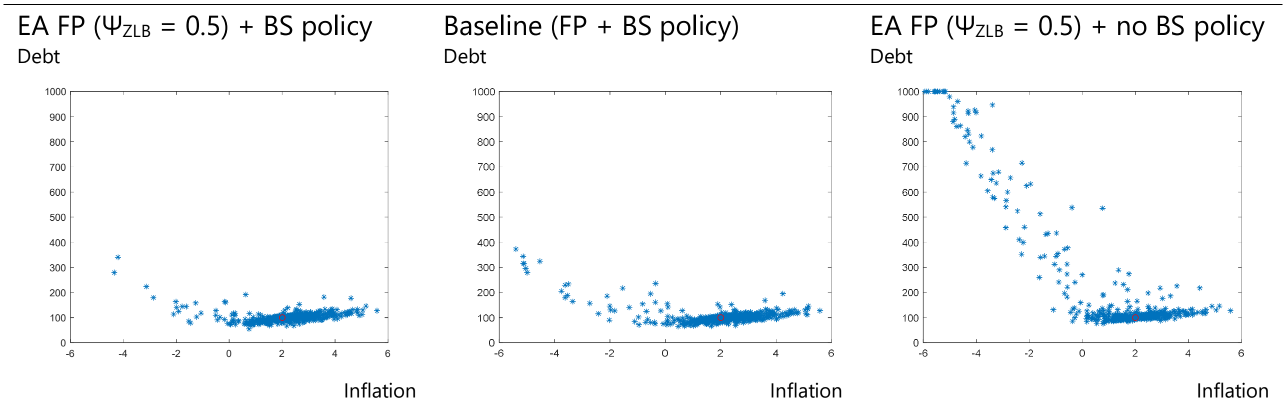
Figure 4: Inflation distribution with debt-averse fiscal policy vs baseline

Debt-averse fiscal policy (δ=0.04) | Baseline (δ=0.01)



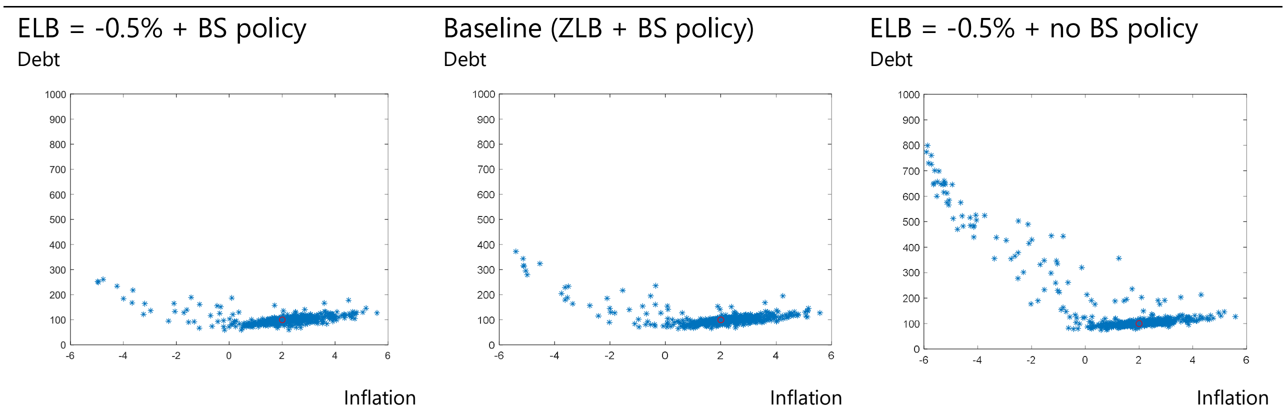
Average realisations over long-horizon simulations

Figure 5: Debt and inflation with extra-accommodative fiscal policy at ZLB vs baseline



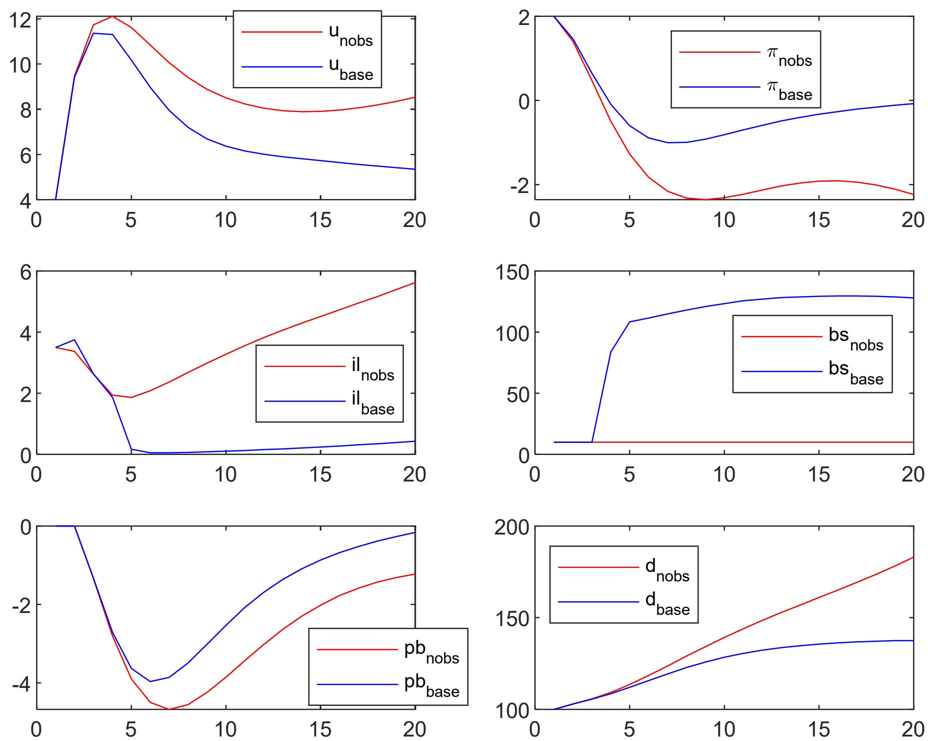
Average realisations over long-horizon simulations

Figure 6: Debt and inflation with negative rates vs baseline



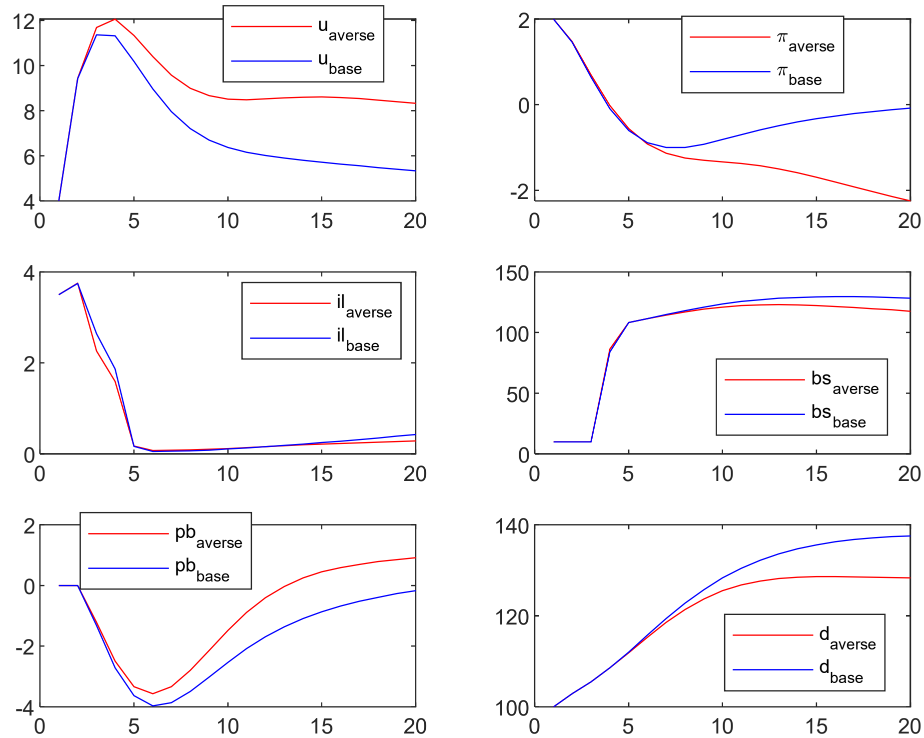
Average realisations over long-horizon simulations

Figure 7: Central bank balance sheet policy in a deep recession



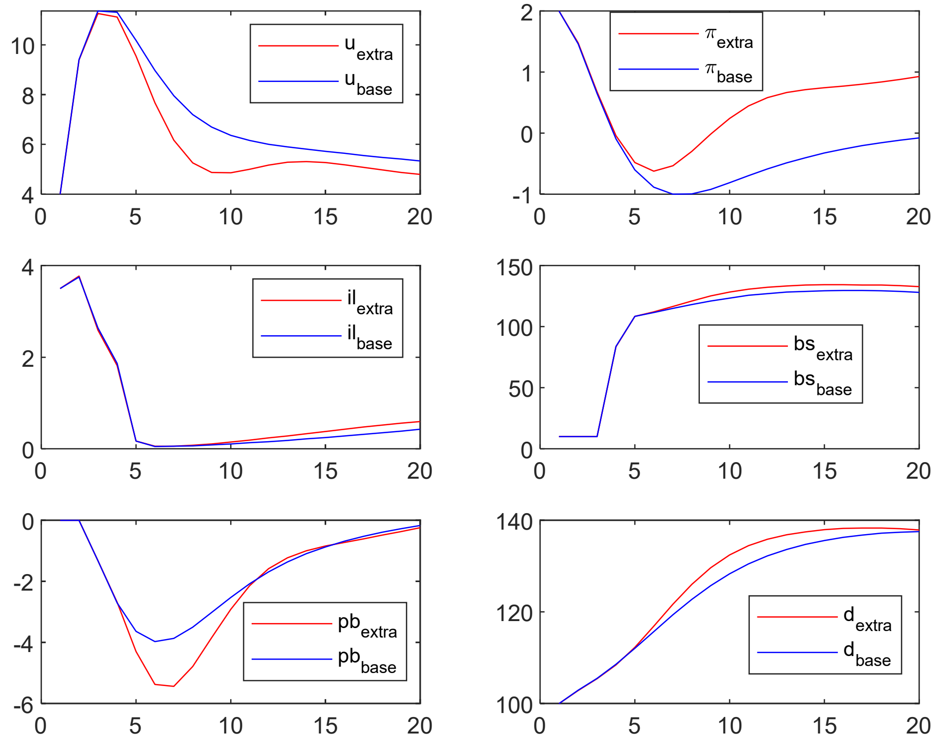
Red lines: No central bank balance sheet policy. Blue lines: Baseline calibration (central bank balance sheet policy activated).

Figure 8: Debt-averse fiscal policy in a deep recession



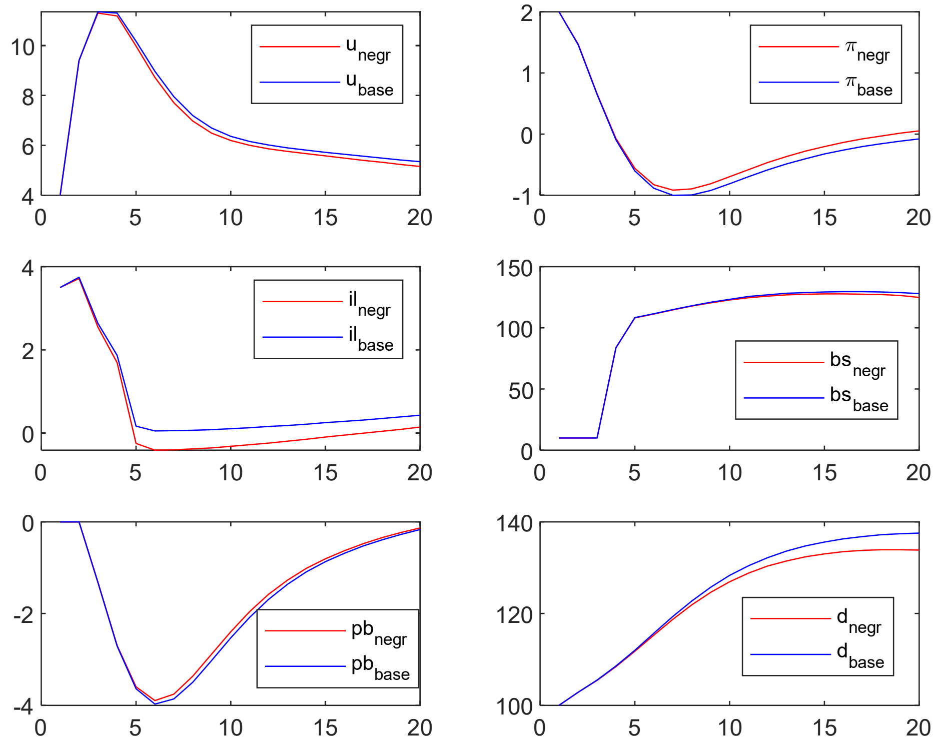
Red lines: Fiscal policy aims for a faster return of public debt to steady state. Blue lines: Baseline calibration.

Figure 9: Extra supportive fiscal policy at the ZLB in a deep recession



Red lines: Fiscal policy provides additional accommodation when policy rates hit the ZLB. Blue lines: Baseline calibration.

Figure 10: Negative rates in a deep recession



Red lines: ELB = -0.5%. Blue lines: ZLB. Baseline calibrations.

Tables

Table 1: The constraining effects of low natural rates over long horizons

	u	*pi*	*rs*	*rl*	*bs*	*pb*	*d*	*ZLB_s*	*ZLB_l*
				FP, r*=2.5					
Mean	4.4	1.5	2.5	3.9	10.0	0.6	113.1	10%	0%
Stdev	0.7	1.6	1.0	0.6	0.0	0.4	12.6		
				FP, r*=0.5					
Mean	4.9	1.1	1.0	2.6	10.0	0.4	134.8	20%	0%
Stdev	0.8	1.6	1.1	0.8	0.0	0.6	24.4		
				FP, r*=0.5, no ZLB					
Mean	4.0	2.0	0.5	1.5	10.0	0.0	100.5	0%	0%
Stdev	0.5	1.5	1.0	0.5	0.0	0.3	4.7		

Average realisations over long-horizon simulations

Table 2: The stabilising effects of central bank balance sheet policy over long horizons

	u	*pi*	*rs*	*rl*	*bs*	*pb*	*d*	*ZLB_s*	*ZLB_l*	*NegTP*
				FP (no BS)						
Mean	4.9	1.1	1.0	2.6	10.0	0.4	134.8	20%	0%	0%
Stdev	0.8	1.6	1.1	0.8	0.0	0.6	24.4			
				FP + BS						
Mean	4.0	2.0	1.1	1.6	22.2	0.0	100.4	9%	14%	28%
Stdev	0.6	1.6	1.0	0.6	8.8	0.3	6.8			

Average realisations over long-horizon simulations

Table 3: The effects of debt-averse fiscal policy over long horizons

	u	*pi*	*rs*	*rl*	*bs*	*pb*	*d*	*ZLB_s*	*ZLB_l*	*NegTP*
				Debt-averse FP+BS, δ=0.04, r*=0.5						
Mean	4.3	1.6	1.2	1.7	27.3	0.1	102.6	15%	21%	28%
Stdev	0.8	1.7	1.2	0.9	11.8	0.4	5.1			
				Benchmark FP+BS, r*=0.5						
Mean	4.0	2.0	1.1	1.6	22.2	0.0	100.4	9%	14%	28%
Stdev	0.6	1.6	1.0	0.6	8.8	0.3	6.8			

Average realisations over long-horizon simulations