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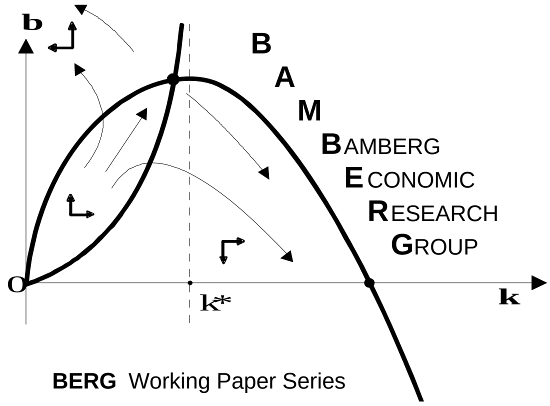

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Animal Spirits, Risk Premia and Monetary Policy at the Zero Lower Bound

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Abstract

In this paper we investigate the risk-related effects of monetary policy both in normal times, as well as in periods where the zero lower bound (ZLB) binds, in a stylized macroeconomic model with boundedly rational beliefs. In our model, financial market participants use heuristics to assess the risk premium over the policy rate in accordance to an "implicit Taylor rule" that measures the stance of conventional monetary policy and which serves as an informative instrument during times when the funds rate is constrained by the ZLB. In such a case, conventional monetary policy is exhausted so that the central bank is forced to use unconventional types of policy. We propose alternative monetary policy measures to help the economy out of the liquidity trap which take into account this assumed form of bounded rationality.

Keywords: Behavioral Macroeconomics, Monetary Policy, Zero Lower Bound, Bounded Rationality

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1 Introduction

In the aftermath of the 2007 Global Financial Crisis the conduct of monetary policy at the zero lower bound (ZLB) shifted from being a mostly theoretical scenario (if Japan's experience since the 1990s is excluded) to the "new normal" for many industrialized economies. Confronted with this new situation, central banks began to implement various types of unconventional monetary policies intending to stimulate economic activity back to pre-crisis levels.

Amongst the various types of unconventional monetary policies available to central banks, the "management of expectations" has been widely investigated at the theoretical level since Krugman's (1998) seminal contribution. As discussed e.g. by Krugman (1998) and Eggertsson and Woodford (2003), a forward-guidance policy seeks to anchor the agents' expectations by means of simple communication. This can be done by the explicit announcement of the future path of short-term interest rates, or by an unspecified commitment to the fulfillment of a particular target. Accordingly, a public commitment by the central bank to keep interest rates low for a time in the future may create inflationary expectations in the present given the forward-looking nature of the agents' economic decisions, thus boosting aggregate demand in the present. The effectiveness of forward-guidance, and in general of the different types of unconventional monetary policies that were implemented since the 2007/08 financial crisis, is however still a matter of debate, see e.g. Gagnon et al. (2010), Fuhrer and Olivei (2011), Hamilton and Wu (2012) and Wu and Xia (2016).

As pointed out by Gabaix (2018), while most of the analysis of the effects of forward guidance is based on the assumption of rational expectations (what often leads to an excess sensitivity of consumption to interest rate changes, see also Del Negro et al., 2015 and McKay et al., 2016), it is worthwhile to investigate this highly relevant issue from a behavioral perspective. Against this background, we explore the functioning and effectiveness of monetary policy in a behavioral macroeconomic framework characterized by endogenously determined attitudes (optimism or pessimism) by the economic agents, which determine in turn the risk premium in the interest rates which are relevant for the households' economic decisions. In particular, these "biased beliefs" become more relevant at the ZLB, where their strength depends on the agents' assessment concerning a "policy rate adequacy gap", which we define as the difference between the actual policy rate and the interest rate prescribed by standard Taylor rule unconstrained by the ZLB. While in normal times, these two interest rates are the same, at the ZLB a potential gap between the two rates emerges, as the latter can become strictly negative. The larger this ZLB policy rate gap is, the more conventional monetary (interest rate) policy is constrained by the ZLB and the greater is the need for unconventional measures. We assume that this ZLB policy rate gap drives the agents' beliefs, increasing the risk premium and making thus the functioning and transmission of monetary policy much more complex than in standard linear rational expectations models. Our model differs thus from the framework studied in Gabaix (2018), for instance, in that our agents' perceptions on macroeconomy are state-dependent and the main question does not reduce to a matter of the agents' degree of rationality. Instead, it allows explicitly for the existence of endogenously determined swings of pessimism during ZLB periods that are then responsible for systematic increases in the risk premium on the interest rate (relevant for the households' consumption decisions), as well as for the government's financing conditions.

Related work by Reifschneider and Williams (2000), Coibion et al. (2012), Williams (2009) and more recently, Kiley and Roberts (2017) and Bernanke (2017) have also investigated, though from a different perspective, the role of the ZLB policy rate gap for the conduct of monetary policy in a low inflation environment. According to this body of the literature, the central bank should keep track of the accommodation foregone because of the ZLB (measured as the sum of the past ZLB policy rate gaps) and commit to make up some of the foregone accomodation in the near future. This leads the central bank to keep the policy rate low by a longer period than prescribed by a traditional Taylor rule, allowing thus inflation to rise above the long-run target after low inflation, or even deflationary periods.

Further, we investigate another alternative monetary policy strategy related to the management of expectations which was already discussed by Krugman (1998) and which was recently brought back to the policy debate by Blanchard et al. (2010), Ball (2013) and others, namely the increase of the central bank's inflation target in order to create higher inflation expectations. According to these authors, a permanent higher inflation target may also be helpful to avoid the risk of pushing the economy into a deflationary environment in normal times, as the likelihood of ZLB events may have been underestimated, as shown by Chung et al. (2012). A recent similar contribution by De Grauwe and Ji (2016) illustrates that the economy suffers from "chronic pessimism" that leads to more recessions and deflationary territories when the central bank faces a low (close to zero) inflation target. Consistent with Blanchard et al. (2010), they conclude that central banks should rather increase their inflation target persistently up to a range of 3% to 4%, thus lowering the probability of negative output gap territories and the risk of hitting the ZLB is lower. By contrast, we consider in the present paper a strategy where the central bank adopts a target of 2% during "normal" times and a higher (and endogenously determined) inflation target when the policy rate hits the zero bound, and that this endogenous target policy is credible at least to a fraction of households.

The remainder of the paper is as follows. In the following section we describe our theoretical framework and its basic transmission mechanisms. In section 3 we discuss the dynamics of the model under conventional (interest rate) monetary policy, while in section 4 we investigate the performance of alternative monetary strategies which take into account the existence of boundedly rational risk perceptions particularly at the ZLB. Section 4 draws some concluding remarks from this study.

2 A Behavioral Macroeconomic Framework

The nonlinear specification of the agents' attitudes play the central role in our behavioral macroeconomic framework. Therefore, for the sake of tractability, for tractability reasons we set up the remaining behavioral equations in terms of log deviations from the model's steady state, which we consider as exogenous, as done e.g. in Woodford (2013).[1] Further, we make use of the level expressions to link the main economic variables as well as to define market equilibria. Accordingly, we have

$$X_t = \exp(\ln(\mathbb{X}_t) + x_t),$$

where X_t represents the level of the variable X_t, $\mathbb{X}_t$ its steady state value (assumed to be constant, i.e. $\mathbb{X}_t = \bar{\mathbb{X}}$) and x_t the log deviation of X_t from $\mathbb{X}_t$.

2.1 Households' Consumption

Households' aggregate consumption is described by a simple Euler-type specification

$$c_t = \tilde{E}_t[c_{t+1}] - \sigma^{-1}(r_t - \tilde{E}_t[\pi_{t+1}] - r^*) + \epsilon_t^c, \tag{1}$$

[1] In Woodford's (2013) analysis, this deterministic steady state is characterized by perfect foresight by all agents and monetary and fiscal policies which are consistent with a zero inflation rate. Our model framework could be interpreted along his lines.

where c_t describes household's level of consumption C_t as log-deviation from its long-term level $\mathbb{C}$, $\tilde{E}_t[c_{t+1}]$ is the subjective expectations of the log-deviation consumption in the next period, r_t represents the nominal interest rate relevant for the household's economic decisions (to be defined below), $\tilde{E}_t\pi_{t+1}$ the expected inflation rate, r^* the equilibrium real interest rate and ϵ_t^c a stochastic disturbance which follows an ordinary stationary AR(1) process.

Along the lines of e.g. De Grauwe (2012) we assume that households switch between two different rules-of-thumb concerning their consumption expectations:

$$E_t^p[c_{t+1}] = \alpha_c y_{t-1}, \quad 0 < \alpha_c < 1, \tag{2}$$

$$E_t^o[c_{t+1}] = 0. \tag{3}$$

According to the first (*p*ersistent) rule, deviations from private consumption from its steady state value are linked linearly with the past output gap $y_{t-1} = \ln(Y_{t-1}/\mathbb{Y})$: If $y_{t-1} > 0$, private consumption will be expected to be above its long-run value, i.e. $E_t^p[c_{t+1}] = \alpha_c y_{t-1} > 0$, and vice versa. On the contrary, the second rule predicts that private consumption will be at its steady state in the next period, regardless of its current level, see also De Grauwe (2012).

As it is standard in this strain of the literature (see e.g. Brock and Hommes, 1997 and Branch and McGough, 2009) the aggregate consumption expectations are given by

$$\tilde{E}_t[c_{t+1}] = \omega_t^p E_t^p[c_{t+1}] + (1-\omega_t^p)E_t^o[c_{t+1}]. \tag{4}$$

where ω_t^p represents the endogenously determined relative weight of of the *persistent* expectations in the aggregate expectations as defined below.[2]

Analogously, agents switch between the following expectational rules-of-thumb concerning future inflation:

$$E_t^p[\pi_{t+1}] = \pi_{t-1}, \tag{5}$$

$$E_t^o[\pi_{t+1}] = \pi^*. \tag{6}$$

The aggregate inflation expectations are then given by

$$\begin{aligned} \tilde{E}_t[\pi_{t+1}] &= \omega_t^p E_t^p[\pi_{t+1}] + (1-\omega_t^p)E_t^o[\pi_{t+1}], \\ &= \omega_t^p \pi_{t-1} + (1-\omega_t^p)\pi^*. \end{aligned} \tag{7}$$

[2]For the sake of simplicity we assume that the endogenously determined relative weight of of the *persistent* expectations ω_t^p is the same both for output and inflation expectations.

2.2 Fiscal Policy

We assume that the government expenditure are determined by the following simple rule (expressed in log deviations of government spending G_t from its long-term counterpart $\mathbb{G}$):

$$g_t = -\phi_{gy} y_{t-1} - \phi_{gb} \left(b_{t-1} - \bar{b} \right). \tag{8}$$

Accordingly, government spending is a negative function of the past output gap and of the deviation of the past debt-to-GDP ratio $b_{t-1} = B_{t-1}/Y_{t-1}$ from the target $\bar{b} = \mathbb{B}/\mathbb{Y}$.[3]

Furthermore, the government is assumed to finance its expenditures and outstanding debt by levying taxes and through issuance of new bonds. Under these assumptions, the governments' flow budget constraint in nominal terms is described by

$$P_t G_t + (1 + r_{t-1}) P_{t-1} B_{t-1} = P_t T_t + P_t B_t.$$

The (real) debt-GDP ratio is then obtained by dividing the latter equation by output Y_t and prices P_t, hence

$$b_t \equiv \frac{B_t}{Y_t} = \frac{1 + r_{t-1}}{(1 + \pi_t)(1 + \hat{Y}_t)} b_{t-1} + \frac{G_t - T_t}{Y_t}. \tag{9}$$

The term $\hat{Y}_t$ measures the growth rate of real output and T_t is the level of tax revenues which is determined by $T_t = \mathbb{T} \exp(y_t)^{\tau_y}$ where $\mathbb{T}$ is the long-run tax revenue when the economy operates at its potential.

Putting all pieces together, the output gap y_t can thus be derived by log-linearizing the market clearing identity $Y_t = C_t + G_t$ around the level of potential output $\mathbb{Y}$. Therefore, aggregate demand in terms of deviations around the potential level becomes

$$y_t = \theta_c c_t + \theta_g g_t \tag{10}$$

where $\theta_c = \mathbb{C}/\mathbb{Y}$ is the household's exogenous propensity to consume and $\theta_g = \mathbb{G}/\mathbb{Y}$ is the government's long-term expenditure-GDP ratio.

[3] Mayer and Stähler (2013), using a DSGE framework, analyze also the performance of a balanced budget rule, finding that due to erratic spending behavior, the balance budget rule tends to destabilize the economic and gives rise to sunspot equilibria. Cyclical fluctuations tend to be more pronounced under this regime, as cyclical smoothing does not take place. Such a regime has also a comparatively poor in terms of welfare.

2.3 Aggregate Supply

We follow the standard assumption that firms' production is determined by aggregate demand and that they set their prices as a function of the output gap and their subjective inflation expectations, i.e.

$$\pi_t = \kappa y_t + \tilde{E}_t[\pi_{t+1}] + \epsilon_t^{\pi}. \tag{11}$$

where π_t denotes price inflation, ϵ_t^{π} is a stochastic shock term, $\kappa > 0$ being the slope coefficient of traditional Phillips curve and $\tilde{E}_t[\pi_{t+1}]$ is given by eq.(7).

2.4 Conventional Monetary Policy and the ZLB Policy Rate Gap

As it is standard in the literature we assume that conventional (interest rate) monetary policy is determined in normal times (i.e. when the ZLB is not binding) by a standard Taylor rule. Accordingly, the short-term nominal policy rate i_t is set equal to the Taylor rule interest rate i_t^{T} which is a function of the gap of (last period's) price inflation from the central bank's inflation target π_t^*, and the (last period's) output gap, i.e.

$$i_t = i_t^{\mathrm{T}} = \phi_i i_{t-1}^{\mathrm{T}} + (1-\phi_i)\left(i^* + \phi_\pi(\pi_{t-1} - \pi^*) + \phi_y y_{t-1}\right) + \varepsilon_t^i, \qquad \forall\ i_t \geq 0, \tag{12}$$

where i^* is the steady-state short-term nominal interest rate, $\phi_\pi > 1$ the coefficient measuring how the policy responds quantitatively to changes in inflation (as deviations from its target rate), $\phi_y > 0$ the central bank's responsiveness to output gap fluctuations, ϕ_i the degree of smoothing in the interest rate setting. By contrast, in times when the ZLB becomes binding, the short-term policy interest rate i_t cannot become negative ($i_t \geq 0$), even though the Taylor rate i_t^{T} may be negative. This case is not only problematic for the monetary authority since conventional monetary policy becomes totally exhausted; it also implies the actual interest rate can no longer signal any information concerning the monetary policy's stance.

Figure 1 illustrates the difference between i_t and i_t^{T} for the case of the United States as discussed by Bernanke (2015).[4] As this Figure clearly illustrates, while the federal funds rate is constrained by the ZLB, the unconstrained Taylor rule (using core PCE inflation and $\phi_y = 1$, as done by Bernanke, 2015) implied for the period from the year 2009 to the

[4] Bernanke and Blinder (1992, p.901ff) argue on the basis of empirical evidence that the federal funds rate is a "good indicator of monetary policy actions [...] mostly driven by policy decisions".

beginning of 2015 that the policy interest rate should have been strongly negative given the macroeconomic conditions summarized by the inflation rate and the output gap.[5]

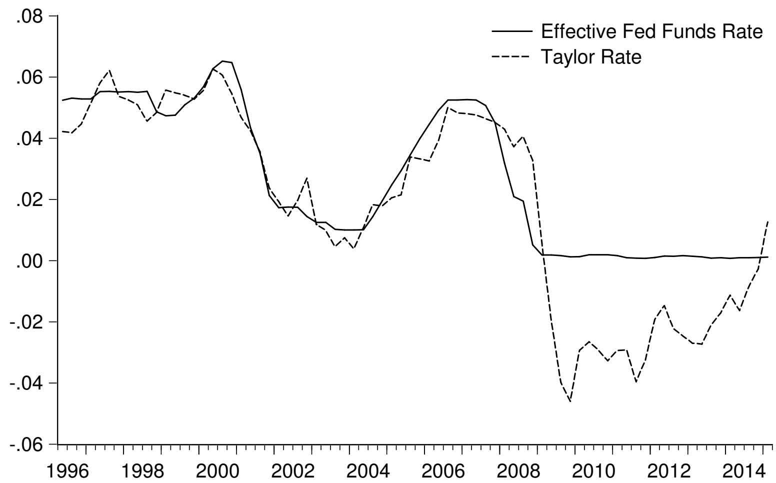

Figure 1: The U.S. Effective Federal Funds Rate, and the Taylor Rate as computed by Bernanke (2015).

In our framework, we assume that the difference between the actual policy rate i_t and the unconstrained Taylor rate i_t^{T} (what we call the ZLB policy rate gap) is considered by the agents as a measure of undone or required accommodation by conventional monetary policy (see e.g Reifschneider and Williams, 2000 and Kiley and Roberts, 2017), and that this measure drives market sentiments. We discuss this mechanism in the next part of this section.

2.5 Animal Spirits and Risk Premia

In the following we assume that the public is aware of the central bank following the Taylor rule and that it may explicitly calculate or even estimate it, and that it evaluates the "adequacy" of the current stance of conventional monetary policy on the basis of the gap between i_t and i_t^{T} (the ZLB policy rate adequacy gap).

[5]Note that the concept of the unconstrained Taylor rate differs from the shadow rate concept proposed and estimated by Bullard (2012) and Wu and Xia (2016), which instead measures the stance of monetary policy when taking into account the effects of unconventional policies.

The relative populations of agents using the persistent and the "long-run equilibrium" expectations $E_t^p[\cdot]$ and $E_t^o[\cdot]$, respectively, are determined through a binary choice approach (see Brock and Hommes, 1997), namely

$$\begin{aligned} \omega_t^p &= \frac{\exp\left(\mu(i_t - i_t^{\mathrm{T}})\right)}{1 + \exp\left(\mu(i_t - i_t^{\mathrm{T}})\right)} \\ \omega_t^o &= 1 - \omega_t^p \end{aligned} \tag{13}$$

where the parameter $\mu \geq 0$ is known as the intensity of choice. According to eq. (13), positive deviations of the actual policy rate from the corresponding implicit Taylor-rule rate (which occur solely at the ZLB) lead to an increase in the number of agents with persistent expectations $E_t^p[\cdot]$ in the market and vice-versa.[6]

A measure for ZLB-related animal spirits is

$$A_t = \omega_t^p - \omega_t^o, \qquad A_t \in [-1, 1]. \tag{14}$$

This specification possesses the property that A_t is bounded between -1 and 1, $A_t \in [-1, 1]$, where in steady state, the variable takes on 0. A positive value of A_t reflects a majority of agents using "persistent" expectations (which are in fact "pessimistic expectations", see footnote 6).

Further, we assume that the "fundamentals-based" risk premium over the risk-free rate is determined according to

$$\zeta_t = \xi_a A_{t-1} - \xi_y y_{t-1} + +\xi_b \left(b_{t-1} - \bar{b}\right) + \xi_\pi |\tilde{E}_t[\pi_{t+1}] - \pi^*| + \epsilon_t^\zeta, \tag{15}$$

where ξ_a, ξ_y, ξ_b and ξ_π are positive coefficients determining the impact of some macroeconomic variables on the aggregate macroeconomic risk and ε_t^ζ represents a stochastic shock which follows an AR(1)-process. In particular we focus on the the general business climate or market mood A_t, the output gap, the debt-to-GDP ratio (as deviation from the reference value $\bar{b}$) and the absolute deviation of the aggregate inflation expectations from the central bank's target π^* (as both positive and negative deviations may be considered equally "bad" by the economic agents). Consistently with the estimates of Adrian et al. (2010), we assume that the output gap is negatively associated with the risk premium on bonds, which can be related to the risk perceptions of the market participants. Further, consistently with the specification

[6]Note that $i_t - i_t^{\mathrm{T}} > 0$ only if $i_t = 0$ and $i_t^{\mathrm{T}} < 0$, what is likely to occur during an economic recession with $y_{t-1} < 0$, $\pi_{t-1} < 0$, or both. If $y_{t-1} < 0$, it follows that $E_t^p(c_{t+1}) = \alpha_c y_{t-1} < 0$.

of Quint and Rabanal (2014), we also assume that the real debt-GDP ratio enters positively in eq. (15) since the more debt is accumulated, the more probable is the debt default and thus the higher the debt default risk. Further, the market mood A_t represents the perception of the majority of market intermediaries concerning the undone accommodation of conventional monetary policy due to the ZLB. In normal times, where the ZLB is not binding, $i_t = i_t^{\mathrm{T}}$, the market mood variable A_t becomes zero, playing therefore no role in the determination of ζ_t, see eq. (15). At the ZLB, on the contrary, $i_t = 0$, while i_t^{T} may be strongly negative. According to eq. (13) this leads to an increase in the amount of households using the $E_t^p[\,\cdot\,]$ expectations, and thus to a deterioration of the market mood which in turn creates an upward bias in the perception of macroeconomic risk.

Finally, the nominal interest rate relevant for the economic decisions of households and of the government is equal the short-term policy rate plus the perceived risk premium in the financial markets (see e.g. Quint and Rabanal 2014), which here is simply given by ζ_t, i.e.

$$r_t = i_t + \zeta_t. \tag{16}$$

As we will discuss later, our model will allow for variations in the risky rate during the ZLB partly as a result of the assessment of risk related with the lack of accommodation of conventional monetary policy due to the ZLB, as previously discussed, as well as due to other macroeconomic fundamentals. Our model will thus allow for a varying spread between the risky and the policy rate: a spread that is existent in normal times, and which we assume becomes even more relevant at the ZLB, when conventional interest policy is exhausted and only unconventional policies are available to the monetary authorities.

3 Model Analysis

3.1 Parametrization

Since the present framework deviates in various dimensions from standard DSGE models, the choice of the model's parameters is not quite straightforward.[7] However, whenever possible, we use parameters widely accepted in the literature. In particular, we set the long-run trend components of consumption, government expenditures and lump-sum taxes $\mathbb{C}$, $\mathbb{G}$ and

[7] Additionally, an estimation of the present model seems quite problematic because of the limited availability of ZLB periods.

$\mathbb{T}$ such that in the long-run steady state private consumption to GDP ratio equals 0.8, the government expenditures to GDP ratio 0.2 (implying thus a ratio of private to government consumption of four), and a balanced government budget, as it is standard in the literature, see e.g. Beetsma and Jensen (2005). As the steady state risky rate is equal to zero, the government debt-to-GDP ratio can be arbitrary, so we set it equal to 0.60, a standard value in the literature and also a value given by the European Maastricht Criteria.

Table 1: Baseline Parameterization

Parameter	Symbol	Value
Interest rate elasticity of consumption	σ	2.00
Output gap elasticity of cyclical government expenditures	ϕ_{gy}	0.50
Government debt elasticity of cyclical government expenditures	ϕ_{gb}	0.10
Output gap elasticity of cyclical tax revenues	τ_y	0.20
Output gap elasticity of price inflation	κ	0.15
Interest rate smoothing parameter	ϕ_i	0.20
Inflation gap coefficient in interest rule	ϕ_π	1.50
Output gap coefficient in interest rule	ϕ_y	0.50
Long-term nominal interest rate	i_o	0.02
Central bank's inflation target	$\pi^\star$	0.02
Share of steady state consumption on output $\mathbb{C}/\mathbb{Y}$	θ_c	0.80
Share of steady state government expenditures on output $\mathbb{G}/\mathbb{Y}$	θ_g	0.20
Share of steady state taxes on output	$\mathbb{T}/\mathbb{Y}$	0.20
Target Debt-to-GDP ratio	$\bar{b}$	0.60
Degree of persistence of extrapolative consumption expectations	α_c	0.90
Intensity of choice parameter	μ	10.0
Animal spirits herding parameter in the risk premium	ξ_a	0.10
Output gap coefficient in the market's risk perceptions	ξ_y	0.05
Government debt coefficient in the market's risk perceptions	ξ_b	0.015
Return differential coefficient in the market's risk expectations	ξ_r	0.2

The real interest rate elasticity of consumption demand (more precisely, the log-linear approximation around its steady state level) given by σ has been estimated independently times by a number of authors. Although these estimates refer to the New Keynesian baseline model including rational expectations, we use the value $\sigma = 2.00$ obtained by McCallum and Nelson (1999). Further, we set the slope of the Phillips curve equal to 0.15 based on the empirical estimates of Goodhart and Hofmann (2005). The government sector parameters are set along the lines of the empirical estimates of Galí and Perotti (2003), namely $\phi_{gb} = 0.1$, and $\phi_{gy} = 0.50$ and $t_y = 0.2$, implying total cyclical elasticity of the structural budget deficit of the order of magnitude of 0.3, see also Mayer and Stähler (2013). Concerning the monetary policy rule, we assume that $\phi_\pi = 1.5$ and $\phi_y = 0.50$ as it is standard in the literature, see e.g. Taylor (1993), as well as $\phi_i = 0.2$ to allow for some degree of inertia in the policy rate. With respect to the reaction parameters in the risk equation, given the lack of empirical estimates, we set them arbitrarily to $\xi_a = 0.1$, $\xi_y = 0.05$ and $\xi_\pi = 0.05$. The value of the investors sensitivity to fluctuations in the debt-GDP ratio corresponds to $\xi_b = 0.015$ along the lines of the estimates provided by De Grauwe and Ji (2013, table 1). Table 1 summarizes all these parameter values. Finally, concerning the stochastic shocks to the system, we assume in a standard manner that all of them follow an AR(1) process (with autoregressive coefficients equal to 0.9) and uniform standard deviations equal to 0.002 due to the lack of robust empirical references.[8]

3.2 Model Dynamics under Conventional Monetary Policy

In order to illustrate the functioning of our theoretical framework, we discuss first the dynamic adjustments of the model following a negative aggregate demand shock which lasts for four periods under alternative scenarios. The resulting dynamics are illustrated in Figure 2.

The solid lines correspond to the unrealistic case where the ZLB is not binding (so that the actual nominal interest rate i_t can turn negative), and fiscal policy is completely passive regarding business cycle developments ($\phi_{gy} = 0$). As can be observed, consumption and output decrease due to the negative shock in private consumption, leading to a decrease of inflation and, through the Taylor rule, to a decrease in the nominal interest rate well into the negative domain. The ZLB-related animal spirits do not react, as the ZLB is not binding. But the risk premium does increase due to the negative developments of the output gap and of price inflation, though not significantly as to reverse the overall negative reaction of the risky rate. Further, the government debt-to-GDP ratio increases initially following the fall in output, leading to a contraction in government expenditures which reduces b/y in the medium-run.

[8]Given the significantly nonlinear structure of the present model, an estimation of the model parameters, even by Bayesian methods, is not a straightforward task, also because the recent ZLB period is very short from an econometric point of view.

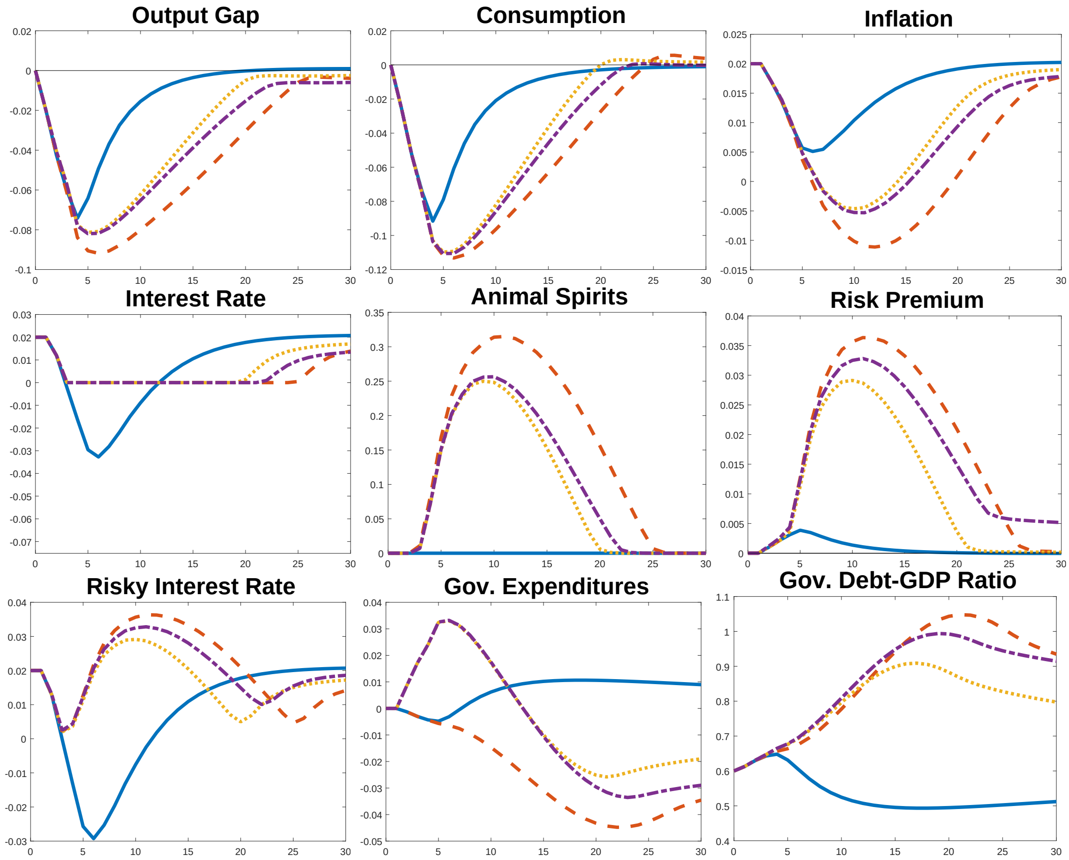

Figure 2: Adjustments after a negative four-period consumption shock $\epsilon_1^c = -0.02$ under no binding ZLB and passive fiscal policy (solid line), binding ZLB and passive fiscal policy (dashed line), binding ZLB, active fiscal policy and no Debt/GDP ratio in risk premium (dotted line) and binding ZLB, active fiscal policy and Debt/GDP in risk premium (dashed-dotted line).

The dashed lined paths illustrate the economy's dynamics when the ZLB binds and fiscal policy is again passive to output gap developments. As it can be observed, consumption, output and inflation remains for a much longer period of time in the negative domain than in the case where the ZLB is not binding. Further, as now ZLB-related spirits are triggered, the increase in the risk premium is much larger, leading over time to an increase in the risky interest rate and to a further depression of consumption, output and price inflation. The pronounced decrease in output leads to a surge in the fiscal debt-to-GDP ratio, which forces the government to reduce expenditures, deepening the economic recession even more.

The dotted- and dashed lines correspond to the two cases where fiscal policy is reactive to the output gap ($\phi_{gy} > 0$) and the risk premium does not react to government debt ($\zeta_b = 0$), and when it does ($\zeta_b > 0$). In both cases, consumption, output and inflation return faster to their respective equilibrium levels than in the previous cases when fiscal policy was not countercyclical. Obviously, this leads to a reduction in the severity of the economic recession, and thus of the increase in the risk premium, particularly in the scenario where the latter does not react to fiscal indebtedness.

Table 2 summarizes the simulated moments resulting from a Monte Carlo simulation of 1000 times 1000 periods for the main variables assuming that in each period the economy is hit by demand, cost-push, risk premium and monetary policy shocks. One can see that the

Table 2: Simulated Moments under Conventional Interest Policy, Percent Values.

Variable	Mean	Std.Dev.	Skewness	Kurtosis
Output (NOZLB, $\phi_{gy} = 0$, $\xi_b = 0$)	-0.105	0.589	-0.025	2.926
(ZLB, $\phi_{gy} = 0$, $\xi_b = 0$)	-0.131	0.579	-0.093	2.920
(ZLB, $\phi_{gy} > 0$, $\xi_b = 0$)	-0.132	0.547	-0.095	2.914
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$)	-0.188	0.570	-0.127	2.929
Inflation (NOZLB, $\phi_{gy} = 0$, $\xi_b = 0$)	1.975	0.711	-0.006	2.896
(ZLB, $\phi_{gy} = 0$, $\xi_b = 0$)	1.967	0.722	-0.072	3.001
(ZLB, $\phi_{gy} > 0$, $\xi_b = 0$)	1.967	0.726	-0.073	2.995
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$)	1.945	0.731	-0.085	3.020
Risky Rate (NOZLB, $\phi_{gy} = 0$, $\xi_b = 0$)	2.053	0.010	0.001	2.911
(ZLB, $\phi_{gy} = 0$, $\xi_b = 0$)	2.069	0.010	0.164	2.682
(ZLB, $\phi_{gy} > 0$, $\xi_b = 0$)	2.067	0.010	0.172	2.671
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$)	2.099	0.010	0.201	2.688
Debt/GDP (NOZLB, $\phi_{gy} = 0$, $\xi_b = 0$)	62.840	0.053	0.255	2.708
(ZLB, $\phi_{gy} = 0$, $\xi_b = 0$)	63.464	0.053	0.323	2.753
(ZLB, $\phi_{gy} > 0$, $\xi_b = 0$)	64.178	0.062	0.339	2.739
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$)	65.959	0.076	0.467	2.779

mean of the output gap in the baseline case (where the ZLB is not binding) is significantly higher (-0.105%) than in all other cases for the same parameter constellation, illustrating the importance of the ZLB constraint for the long-run dynamics of the economy. Indeed, the mean of the output gap in the first scenario where the ZLB binds, but no countercyclical fiscal policy ($\phi_{gy} = 0$) is implemented and the risk-premium is independent from the fiscal stance, is significantly lower (-0.132%) than in the previous case.

It is interesting to note that the implementation of countercyclical fiscal policy, for the given parameter constellation (in particular, for $\xi_b = 0$), does not improve the mean of the long-run output gap significantly relative to the previous case. However, it does reduce the output gap's standard deviation around the long-run median (-0.132%), and having therefore a positive effect, at least in terms of output variability. By contrast, when the risk premium does depend on the government's indebtedness ($\xi_b > 0$), an active countercyclical fiscal policy is detrimental for economic activity, as the increase in the government debt-to-GDP ratio leads to an increase in the risky rate, which in turn depresses economic activity, as the lower median output gap (-0.188%) shows. Regarding the skewness of the output gap distribution, the negative values in all four scenarios indicate a left-tailed distribution, assigning a larger probability of severe economic recessions than economic booms. Finally, the lower-than-three kurtosis values of the output gap in all four scenarios indicate that the probability mass of the simulated values is located more around the mean than in the case of a normal distribution. In this context, the fact that the lowest kurtosis value is the one corresponding to the scenario with an active countercyclical fiscal policy could be interpreted as indicative for a successful macroeconomic stabilization.

These results concerning the output gap are of course intrinsically related with the other model variables. Our Monte Carlo experiment shows that the median of inflation is the lowest, and the risky rate and the debt-to-GDP ratio the highest in the case where the ZLB binds and $\phi_{gy} > 0$ and $\xi_b > 0$.

3.3 Model Dynamics under Forward-Guidance

As discussed e.g. by Krugman (1998) and Eggertsson and Woodford (2003), a forward-guidance policy seeks to anchor the agents' expectations by means of simple communication to the public. This can be done by the explicit announcement of the future path of short-term interest rates, or by the unspecified commitment to the fulfillment of a particular target.

In the following we implement the second alternative and illustrate in Figure 3 the dynamics of the economy following a central bank announcement of the enforce an inflation rate consistent with its target at $t = 8, 9, 10$ which is fully believed in by all market participants. This experiment is similar in spirit to the analysis of Arifovic et al. (2018), where, in a nonlinear New Keynesian model with learning, the rational expectations solution is communicated to a fraction of agents, reshaping thus the aggregate inflation expectations in the economy. Specifically, this implies that the sentiment mechanism described by eq.(14) is temporarily of cancelled off, so that aggregate expected inflation is temporarily equal to π^*, see also eq.(7).

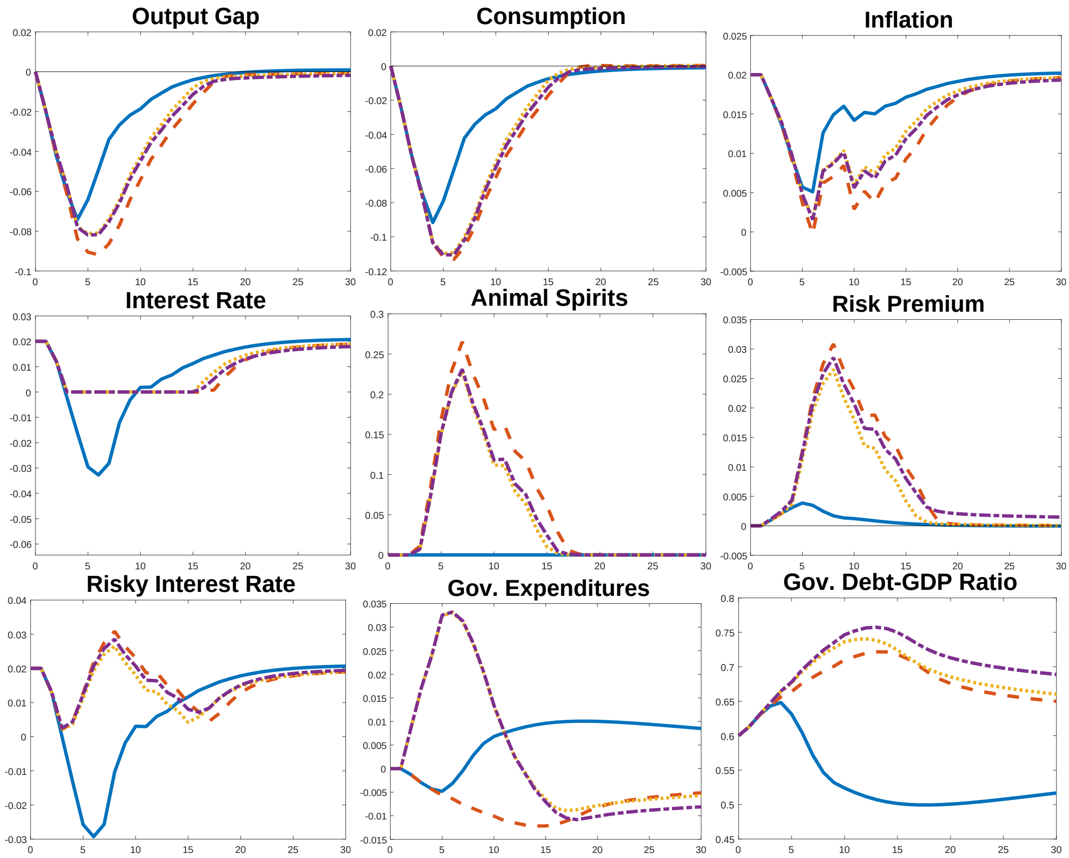

Figure 3: Adjustments after a negative four-period consumption shock $\epsilon_1^c = -0.02$ under no binding ZLB and passive fiscal policy (solid line), binding ZLB and passive fiscal policy (dashed line), binding ZLB, active fiscal policy and no Debt/GDP ratio in risk premium (dotted line) and binding ZLB, active fiscal policy and Debt/GDP in risk premium (dashed-dotted line).

As this figure illustrates, the central bank can achieve, through the anchoring of inflation expectations – and thus the nonlinear disruption of the model dynamics for three periods – an improvement in the macroeconomic conditions and a reduction in the extent and duration of the economic slump. The macroeconomic mechanism behind this result is the following: by managing to anchor the inflation expectations at $\pi^* = 0.02$, the decrease of actual inflation following the reduction in macroeconomic activity is not only stopped, but it in fact increases to about 0.015. This development increases production and consumption, bringing the short term nominal interest rate faster back to a positive level. This in turn reduces the risk premium charged in the financial markets, what is also beneficial for the public finances.

It should be noted that this outcome relies on the unlikely assumption that the central bank's announcement is immediately and fully believed by all economic agents. If the central bank's credibility among the public is endogenous and agents have heterogenous expectations, as investigated e.g. Goy et al. (2018), forward guidance may be less efficient and take longer to bring the economy away from the ZLB.

become effective, and this also to a lower extent.

4 Monetary Policy with Animal Spirits

Now we turn to the analysis of monetary policy rules which take into account the possibility of ZLB-related animal spirits and their feedback in the macroeconomy. More specifically, we consider two alternatives: the modification of the Taylor rule by the inclusion of a risk-premium term (which becomes particularly relevant in ZLB periods due to the animal spirits), and the endogenization of the inflation target as a function of a measure of the ZLB.

4.1 Risk-Premium-Augmented Taylor Rule

As to the first alternative, we investigate the following augmented Taylor type interest rate rule:

$$i_t^{\mathrm{T}} = \phi_i i_{t-1}^{\mathrm{T}} + (1-\phi_i)\left[i_o + \phi_\pi(\pi_{t-1} - \pi^*) + \phi_y y_{t-1} - \phi_\zeta \zeta_{t-1}\right] + \varepsilon_t^i, \quad \text{with } \ \phi_\zeta > 0. \tag{17}$$

According to eq.(17), the central bank will decrease the policy rate by an amount of ϕ_ζ when the risk premium increases. As we have discussed in the previous section, while the risk premium is affected by macroeconomic conditions in both normal and ZLB periods (see eq. 15), an increasing discrepancy between i_t and i_t^{T}, which occurs precisely when the ZLB becomes binding, leads to an additional increase in the risk premium. The specified lag structure assumed for the impact of A_t on i_t^{T}, namely two periods, includes a certain inertia in the policy rate setting, leading thus to a more than usual accommodative interest policy after the ZLB period.[9]

[9] It should be noted that a similar specification has been proposed e.g. by Cúrdia and Woodford (2010),

Table 3: Simulated Moments of Main Model Variables under a Risk-Premium-Augmented Interest Policy

Variable	Mean	Std.Dev.	Skewness	Kurtosis
Output (ZLB, $\phi_{gy} = 0$, $\xi_b = 0$, $\phi_\xi = 0$)	-0.131	0.579	-0.093	2.920
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0$)	-0.188	0.570	-0.127	2.929
(ZLB, $\phi_{gy} = 0$, $\xi_b > 0$, $\phi_\xi = 0.5$)	-0.067	0.571	-0.086	2.941
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0.5$)	-0.069	0.541	-0.089	2.933
Inflation (ZLB, $\phi_{gy} = 0$, $\xi_b = 0$, $\phi_\xi = 0$)	1.967	0.722	-0.072	3.001
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0$)	1.945	0.731	-0.085	3.020
(ZLB, $\phi_{gy} = 0$, $\xi_b > 0$, $\phi_\xi = 0.5$)	1.985	0.721	-0.076	3.004
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0.5$)	1.984	0.725	-0.076	3.004
Risky Rate (ZLB, $\phi_{gy} = 0$, $\xi_b = 0$, $\phi_\xi = 0$)	2.069	0.010	0.164	2.682
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0$)	2.099	0.010	0.201	2.688
(ZLB, $\phi_{gy} = 0$, $\xi_b > 0$, $\phi_\xi = 0.5$)	2.042	0.010	0.167	2.667
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0.5$)	2.040	0.010	0.173	2.663
Debt/GDP (ZLB, $\phi_{gy} = 0$, $\xi_b = 0$, $\phi_\xi = 0$)	63.464	0.053	0.323	2.753
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0$)	65.959	0.076	0.467	2.779
(ZLB, $\phi_{gy} = 0$, $\xi_b > 0$, $\phi_\xi = 0.5$)	61.724	0.051	0.323	2.781
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0.5$)	62.144	0.060	0.340	2.765

Analogously to Table 2, Table 3 summarizes the simulated moments resulting from Monte Carlo simulations under the assumption of a risk-augmented interest rule as specified by eq.(17). For each variable, the first and the second rows in this table correspond to the second row and the fourth rows in Table 2, while the third and the fourth rows illustrate the effects of the inclusion of the risk-premium term in the interest rule under a passive (third row) and a countercyclical fiscal policy.

A number of important and interesting results are to be highlighted. Concerning the output gap, our simulations suggest that the inclusion of the risk-premium term into the Taylor rule leads to an improvement of the output gap mean relative to the passive and

but was based on a completely different theoretical framework and economic perspective. While these authors set up a medium-scale DSGE Model with financial frictions based on rational expectations, our specification is based on the premise that agents use behavioral rules-of-thumb to form their expectations about future output and inflation developments, and that the ZLB triggers "animal spirits", which rise the risk premium on the interest rate relevant for both households and fiscal authorities.

countercyclical fiscal policy scenario, both when the risk premium is and is not reactive to government debt. Interestingly, the scenario with the lowest output gap is the one where fiscal policy is passive (third row), even though the difference with the countercyclical fiscal policy scenario (fourth row) is relatively small. Regarding inflation, the implementation of the risk premium-augmented interest rule under $\phi_{gy} = 0$ and under $\phi_{gy} > 0$ generates means 1.985% and 1.984% closer to the target of 2% than the standard rules (1.967% and 1.945%), and thus, better outcomes with respect to inflation stabilization.

The accommodative policy rate induced by the inclusion of the risk premium term is also associated with lower average risky rates, as well as with lower government indebtedness levels. However, in contrast to the output gap and inflation variables, the simulated risky rate and the debt-to-GDP ratio feature both right-tailed distributions, which highlights the nonlinear structure of the model.

4.2 Endogenous Inflation Target

There is a broad literature concerning the question of whether a variation of the inflation target may be beneficial in the presence of the ZLB constraint. The particular effect on the state of the economy, however, is not without ambiguity. Some authors argue like Schmitt-Grohe and Uribe (2010) and Coibion et al. (2012), that a change in the inflation target is not a convenient stabilization tool since it does not necessarily reduce the costs arising from the ZLB. They further claim that low inflation targets, close to zero, reduce the probability of reaching the zero bound on interest rates. Consistently with this line of argumentation, Eggertsson and Woodford (2003) show in a simple theoretical exercise that raising the inflation target increases the number of periods when the policy rate hits the ZLB, due to a reduction of the natural rate of interest which is conditional for the ZLB to become a binding constraint. In contrast, De Grauwe and Ji (2016) show that even for low inflation targets, output gap and inflation appear to be more often negative and thus the risk of hitting the zero bound increases. The authors argue that in such a case the economy is subject to “chronic pessimism” which in turn yields an output gap distribution that is skewed towards the negative values. They further show that inflation targets of 3% to 4% (consistent with Blanchard et al., 2010) appear to be optimal, since they lead to a roughly symmetric distribution of the output gap. While De Grauwe and Ji (2016) study the effects of persistent changes in the inflation target, our work is related to the idea of Chattopadhyay and Daniel (2014) who suggest that the central may adopt a time varying inflation target once the ZLB is reached, and a fixed target away from the zero bound. They choose the inflation target as to minimize expected welfare losses. Their policy instrument thus provides a useful tool to communicate and implement a policy which is closely linked to optimal monetary policy. They show that even though higher inflation targets postpone the date of recovery, the period the ZLB disappears and the exit takes place with higher inflation and output gap. Therefore, their findings are implicitly related to the equilibrium selection discussion of Cochrane (2017) since the policy maker can commit to end the zero bound environment at different magnitudes of the output gap and inflation.

In this context, we consider the following specification of an endogenous inflation target

$$\pi_t^* = (1 - \nu_{\pi^*})\pi_{t-1}^* + \nu_{\pi^*}(\pi^* + i_t - i_{t-1}^T). \tag{18}$$

According to this specification, starting from the steady state where $\pi_t^* = \pi^*$, the inflation target π_t^* would be increased at the ZLB in proportion to $i_t - i_{t-1}^T$ i.e., by the ZLB policy gap, and would return to π^* after the ZLB is no longer relevant (with $i_t - i_{t-1}^T = 0$) with a velocity determined by ν_{π^*}.

Analogously to Tables 2 and 3, Table 4 reports the simulated moments of the main model variables under the assumption of an endogenous inflation target as specified by eq.(18) and a binding ZLB. As it can be observed therein, for the first case where fiscal policy is passive ($\phi_{gy} = 0$) and the risk premium is not reactive to government indebtedness ($\xi_b = 0$), the central bank pursues a standard interest rule ($\phi_\xi = 0$), while the mean of the simulated output gaps is nearly zero (0.001%). This rather positive outcome is coupled with a significantly higher inflation rate (2.351%) than in all other cases. The implementation of a time-varying inflation target in an environment where the risk premium is not reactive to the government debt-to-GDP ratio is thus indeed stabilizing, but also inflationary, a result supported also by the values of the third and fourth moments of these variables.

The three other cases under consideration are based on the more realistic assumption that the risk premium reacts positively to increases in the government debt-to-GDP ratio. Two main results must be highlighted: First, the policy mix of a countercyclical fiscal policy and monetary policy with a varying inflation target alone is not beneficial for macroeconomic stability, as it yields a negative output gap mean (-0.262%) and a government debt-to-GDP ratio which is significantly higher (66.974%) than in the other cases. The negative effects of a higher risk premium, which result from an active fiscal spending policy and a subsequently

Table 4: Simulated Moments of Main Model Variables under an Endogenous Inflation Target

Variable	Mean	Std.Dev.	Skewness	Kurtosis
Output (ZLB, $\phi_{gy} = 0$, $\xi_b = 0$, $\phi_\xi = 0$, $\nu_{\pi^*} = 0.5$)	0.001	0.730	0.186	8.643
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0$, $\nu_{\pi^*} = 0.5$)	-0.262	0.610	-0.179	3.457
(ZLB, $\phi_{gy} = 0$, $\xi_b > 0$, $\phi_\xi = 0.5$, $\nu_{\pi^*} = 0.5$)	0.024	0.667	-0.009	5.264
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0.5$, $\nu_{\pi^*} = 0.5$)	0.022	0.631	-0.033	5.032
Inflation (ZLB, $\phi_{gy} = 0$, $\xi_b = 0$, $\phi_\xi = 0$, $\nu_{\pi^*} = 0.5$)	2.398	0.922	1.737	11.273
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0$, $\nu_{\pi^*} = 0.5$)	1.939	0.796	0.030	5.730
(ZLB, $\phi_{gy} = 0$, $\xi_b > 0$, $\phi_\xi = 0.5$, $\nu_{\pi^*} = 0.5$)	2.202	0.863	0.096	7.751
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0.5$, $\nu_{\pi^*} = 0.5$)	2.202	0.862	0.096	7.415
Risky Rate (ZLB, $\phi_{gy} = 0$, $\xi_b = 0$, $\phi_\xi = 0$, $\nu_{\pi^*} = 0.5$)	2.341	0.011	0.585	4.716
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0$, $\nu_{\pi^*} = 0.5$)	2.246	0.010	0.520	3.696
(ZLB, $\phi_{gy} = 0$, $\xi_b > 0$, $\phi_\xi = 0.5$, $\nu_{\pi^*} = 0.5$)	2.313	0.010	0.173	3.978
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0.5$, $\nu_{\pi^*} = 0.5$)	2.312	0.010	0.173	3.754
Debt/GDP (ZLB, $\phi_{gy} = 0$, $\xi_b = 0$, $\phi_\xi = 0$, $\nu_{\pi^*} = 0.5$)	59.468	0.070	-0.337	3.591
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0$, $\nu_{\pi^*} = 0.5$)	66.974	0.088	0.639	3.196
(ZLB, $\phi_{gy} = 0$, $\xi_b > 0$, $\phi_\xi = 0.5$, $\nu_{\pi^*} = 0.5$)	58.745	0.062	0.266	3.151
(ZLB, $\phi_{gy} > 0$, $\xi_b > 0$, $\phi_\xi = 0.5$, $\nu_{\pi^*} = 0.5$)	58.724	0.073	0.307	3.136

higher fiscal debt, are not offset by a varying inflation target, so that the overall effect is negative. Secondly, a monetary policy which is based on a risk premium augmented interest rule and a varying inflation target, leads to almost equivalent positive outcomes concerning all model variables, without or with a countercyclical fiscal spending policy. This is indeed important because of two reasons: First, a varying inflation target as specified in eq.(18) does not generate inflation rates significantly above the standard target of 2%, so that the welfare costs of inflation are not necessarily too high, and second, the small effect of an active fiscal policy in the presence of a monetary policy two-instrument rule relativizes the supposedly effectiveness of the former at the ZLB relative to monetary policy.

5 Concluding Remarks

The 2007 global financial crisis led the world economy to the brink of a new Great Depression and showed that the hitting the ZLB was not only a theoretical possibility or something only happening in Japan, but that it could become a relevant constraint for policy-making in the major industrialized economies.

The subsequent extensive theoretical and empirical research on monetary policy at the ZLB helped to gain a much better understanding of the limits of policy in this situation. Most of the theoretical analysis of the issue was based however on the rational expectations paradigm which is predominant in current macroeconomics. However, as discussed e.g. by Del Negro et al. (2015), McKay et al. (2016) and Gabaix (2018), this assumption often leads to to an excess sensitivity of consumption to interest rate changes, and thus to an overestimation of the power of a forward guidance policy. On the other hand, the literature on heterogenous behavioral expectations has not yet been as proliferous, being Goy et al. (2018) and Hommes and Lustenhouwer (2019*a*, 2019*b*) notable exceptions.

Our simulation analysis unveiled a number of interesting transmission mechanisms and interactions often overlooked in macroeconomic models with rational expectations, and delivered thus important insights for the conduct of monetary policy in the real world. The main results of our analysis can be summarized as follows: First, when the assessment of what we called the “ZLB policy rate gap” plays a role in the risk perceptions of the central bank, a destabilizing feedback mechanism is triggered which is likely to increase the risk perceptions of the economic agents, depressing consumption and output and thus prolonging the ZLB episode. If, in addition, markets disdain fiscal indebtedness, the implementation of countercyclical fiscal policy may not be beneficial, but instead, it may be actually detrimental for macroeconomic stability. Further, we found that making the short term policy rate react negatively to the risk premium in normal times leads to a significant improvement of the output gap, and a better inflation stabilization on average over all simulations.

The most interesting result of our analysis concerns however the interaction between two policy mixes: the monetary policy mix of a risk-premium augmented monetary policy rule and an varying inflation target, and the fiscal-monetary policy mix. Concerning the former, we found that such a mix is indeed much more beneficial for macroeconomic stabilization than the implementation of only one of the two instruments. Concerning the latter, we found that if such a monetary policy mix is implemented, fiscal policy becomes also irrelevant, even if the ZLB is a probable constraint.

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