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# Output Gap Uncertainty, Sovereign Risk Premia and the Contingent Importance of the Bond Vigilantes

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## CAMA Working Paper 27/2025
## May 2025



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## Abstract

This paper investigates the implications of output gap uncertainty for the conduct of fiscal policy using a small-scale macroeconomic model with boundedly rational agents. Specifically, agents use an adaptive updating mechanism to approximate the unobservable potential output that suffers, similarly to the Hodrick and Prescott (1997), from an end-point bias. This generates an unintendedly procyclical fiscal policy that affects the government's credibility and by extension the sovereign risk premium. Our simulations highlight the importance of this so-called bond vigilantes channel, as well as of the government's credibility among financial markets, for the sustainability of government debt and for macroeconomic stability.



**Keywords**

output gap uncertainty, fiscal policy, sovereign risk, government credibility, bounded rationality

**JEL Classification**

E62, E63, H63, E32, D84, G12, D83

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**ISSN 2206-0332**

# Output Gap Uncertainty, Sovereign Risk Premia and the Contingent Importance of the Bond Vigilantes

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April 29, 2025

**Abstract**

This paper investigates the implications of output gap uncertainty for the conduct of fiscal policy using a small-scale macroeconomic model with boundedly rational agents. Specifically, agents use an adaptive updating mechanism to approximate the unobservable potential output that suffers, similarly to the Hodrick and Prescott (1997), from an end-point bias. This generates an unintendedly procyclical fiscal policy that affects the government's credibility and by extension the sovereign risk premium. Our simulations highlight the importance of this so-called bond vigilantes channel, as well as of the government's credibility among financial markets, for the sustainability of government debt and for macroeconomic stability.

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*E-mail: christian.proano@uni-bamberg.de. Financial support by the Macroeconomic Policy Institute (IMK) at the Hans-Böckler Foundation is gratefully acknowledged. We would like to thank Thomas Lux, Frank Westerhoff, Sarah Mignot, Phillip Heimberger as well as participants of the 27th Annual Workshop on Economics with Heterogeneous Interacting Agents in Bamberg, the International Workshop of Economic Complexity and Macroeconomic Dynamics in Valencia, Spain, the 2024 FMM Conference in Berlin, the 2024 CFE Conference in London, UK and the 2025 Eastern Economic Association Conference in New York, USA for helpful comments and suggestions on previous drafts of this paper, as well as Amalia Salas for her excellent research assistance. All remaining errors are ours.

## 1 Introduction

Not least since Arthur Okun's seminal contribution (Okun, 1962), the aggregate "potential output" has been one of the most central concepts in the theoretical and practical design of monetary and fiscal policy (see e.g. Taylor, 1993, 2000, and Kumhof and Laxton, 2013). Using the "potential output" as a guiding measure for economic policy is, however, questionable due to various reasons. First and foremost, being a theoretical concept,[1] the true "potential output" (assuming its actual existence) is not observable in reality. Instead, it has to be indirectly measured or estimated, often with also questionable concepts such as aggregate Cobb-Douglas production functions and/or the non-accelerating rate of unemployment (NAIRU) (see e.g. Gechert et al., 2022 and Hazell et al., 2022 for two recent contributions addressing these two issues, respectively). Further as widely acknowledged, potential output estimates are also subject to the well-known end-point bias problem related to the great majority of available filtering techniques and in particular to the widely popular Hodrick and Prescott (1997) (HP) Filter. As discussed e.g. by Horn et al. (2007), Andrle (2013), and Hamilton (2018), the end-point bias problem leads to a systematic underestimation of the "true" output gap (assuming of course its existence) that may translate into an unintendedly insufficient countercyclical (or even procyclical) reaction of fiscal and monetary policy, as pointed out by Orphanides (2001).

In most theoretical macroeconomic models – including those of the dynamic stochastic general equilibrium (DSGE) variety (see e.g. Woodford, 2003 and Galí, 2015) – the unobservability of potential output plays only a minor rule, as it is often assumed that the current output gap – and thus the current potential output – is or can be directly observable by the private and the public sector mainly because of two reasons: First, as agents in that modeling paradigm are assumed to know and understand fully the true structure and functioning of the economy, there is no need for agents to compute any type of filter to infer what the "potential output level" might be. And second, the definition of the output gap in this type of models is different from the one used in policy-oriented circles: In DSGE models, the output gap that is assumed to be relevant for policy-making is the percent deviation of current output from the *flexible price* output level, i.e. the level of output which would be achieved if there were no nominal (price or wage) rigidities. This is conceptually different from the policy-relevant potential output, which is usually understood as the level of production which would be achieved if all factors of production would be used at their full capacity.[2] Notable exceptions to this standard approach are Cúrdia et al. (2015) and Born and Pfeifer (2014, 2021), who assume in their DSGE models that

[1] Kiley (2013) discusses three alternative potential output definitions that are employed in modern research: a statistical one (the deviation of output from its long-run stochastic trend), a "production-function-based" one (the deviation of output from the level consistent with current technologies and normal utilization of capital and labor input), and a "neoclassical" one (the deviation of output from the "flexible-price" output).

[2] Both concepts may be similar and even the same in some frameworks, but they do not need to be, as discussed e.g. in Aiyar and Voigts (2019).

the central bank estimates the potential output using a two-sided Hodrick-Prescott (HP) filter.[3] The role of uncertainty regarding the potential output for the conduct of monetary policy was already investigated some time ago, though. For example, Smets (2002) shows, using a simple estimated model of the US economy, that output gap uncertainty reduces the response of the Taylor rule rate to the current estimated output gap relative to current inflation, yielding an overall response quite different from the optimal response that would emerge under no uncertainty. Further, focusing on the (also unobservable) natural rates of interest and unemployment, Orphanides and Williams (2002) show that rules optimized under the false premise that misperceptions about these natural rules are small turn out to be particularly costly. Instead, they advocate the use of "difference rules", that is of interest rate rules that react to observable changes in actual economic activity, thus not relying on unobservable variables. Grigoli et al. (2015) find that real-time estimates of the output gap have been highly inaccurate in Latin American countries, and Ley and Misch (2013) find similar results in a broad range of countries.

The unobservability of the "true potential output" (if it even exists) and the well-known end-point bias has also far reaching consequences in Europe, as the EU framework for fiscal policies heavily relies on the estimation of the potential output in real time (see e.g. Proaño, 2013, Fatás, 2019 and Heimberger et al., 2024 for some critical assessments). Against this background, the main aim of this paper is to investigate the implications of output gap uncertainty (resulting from the unobservability of potential output and the use of imperfect techniques such as the HP filter for its approximation/estimation) for the conduct of fiscal policy using a small-scale macroeconomic model with boundedly rational agents along the lines of Proaño and Lojak (2017, 2020). More specifically, agents will be assumed to *not* know the true potential output level given their bounded rationality. Instead, they will try to infer it by detrending actual, observable output using an adaptive updating mechanism that acts as a proxy for more elaborated filtering techniques such as the Hodrick and Prescott (1997) filter. As it is well known, these estimates will suffer by construction, from an end-point bias that may lead to a systematic underestimation of the true difference between the actual and the potential output level, i.e. of the output gap. This in turn will affect the government's credibility, which is endogenized through a binary choice approach along the lines of Brock and Hommes (1997, 1998) (similarly as in De Grauwe, 2012). This approach is adequate for the research question because the potential output, being a theoretical concept, is not directly observable and needs thus to be estimated, most likely in a misspecified way.

Recently, some studies such as Proaño and Lojak (2017), De Grauwe and Foresti (2020) and Lustenhouwer (2020) have investigated from a behavioral perspective the role of expectations for

[3] Note, however, that in these studies, the model-consistent, or rational expectations future values of the relevant variables enter in the calculation of the two-sided HP filter, making the end-point bias problem less binding.

fiscal policy, the evolution of government debt and overall macroeconomic stability. In these studies, however, the discrepancy between the true and the potential output gap is not considered, while here it is one of the central topics. Further, they focus much more on the interplay between monetary and fiscal policy at the zero lower bound (ZLB, as also done in Proaño and Lojak, 2020, 2021), while this will not be the focus in this paper, as price fluctuations and monetary policy will be abstracted from. Finally, while here the government bond rate is assumed to depend on the debt-to-output ratio, in De Grauwe and Foresti (2020) there is no risk premium on government bond and the policy rate is set in a standard way through a Taylor rule. Therefore, the insights which may rise from this analysis may not only be interesting in its own right, but also may be expand the literature on fiscal policy and behavioral heterogenous expectations.

The importance of market perceptions regarding the sustainability of government debt was already discussed by Taylor et al. (2012), who investigated the role of the so-called "bond vigilantes", i.e. of investors' who require higher yields in response to expansionary and/or debt-financed fiscal policies for macroeconomic stability in a stylized macroeconomic model. Therein, the late Lance Taylor and his coauthors highlighted the flawed debate about fiscal austerity and economic growth, quoting the then German finance minister Wolfgang Schäuble's 2010 op-ed at the Financial Times as follows: "restoring confidence in our ability to cut the deficit is a prerequisite for balanced and sustainable growth. Without this confidence there can be no durable growth [. . . ] This is the lesson of the recent crisis. This is what financial markets, in their unambiguous reaction to excessive budget deficits, are telling us and our partners in Europe and elsewhere." As discussed in Taylor et al. (2012), the importance of this fiscal austerity channel is however dependent on the impact of the bond vigilantes on the sovereign risk premium, and thus on the market's perception about the soundness of the implemented fiscal policies.

Against this background, the main results of this paper can be summarized as follows: First, the local stability analysis of the baseline model (without endogenous government credibility) indicates that an adaptive updating of the estimated potential output following current output developments is not per se destabilizing. Second, what determines the local stability of the theoretical model is the condition that the fiscal spending reaction to the debt-to-GDP ratio has to be sufficiently strong *if risk premia is indeed positively influenced by the latter*. This qualification is extremely important: If financial markets care very little for the government's debt-to-GDP ratio and thus the sovereign risk premium is only very mildly sensitive to it (in other words, if bond vigilantes are not particularly important), then fiscal policy is not required to react to the debt-to-GDP ratio for macroeconomic stabilization purposes. This finding is in line with Proaño et al. (2014) who, using a dynamic panel threshold approach, find that the government debt-to-GDP ratio exerts only a statistically significant negative effect on economic growth when financial market stress is high, but not otherwise. And third, the credibility of the government's fiscal policy efficiency plays also an important role in macro-financial volatility through its effect on the sovereign risk premium.

The remainder of this paper is organized as follows: The baseline theoretical model is described in Section 2. The local stability conditions of the log-linearized version of the baseline model, and the model's dynamic adjustments are discussed in Sections 3 and 4. The interplay between output gap uncertainty and endogenous government credibility is investigated in Section 5 where Section 6 adds a further extension with weak hysteresis. Section 7 draws some concluding remarks from this study and outlines some possible extensions of this framework.

## 2 The Baseline Model

The baseline model presented in this section abstracts from aggregate investment, employment dynamics, price and wage inflation, and monetary policy, with private consumption and government spending being the only components of aggregate demand that are explicitly modeled, and with sovereign risk being also endogenously determined in a linear manner without any non-linear switching mechanisms. In section 5, this latter variable will be endogenized to represent the government's policy credibility using a similar adaptation of the Brock and Hommes (1998) mechanism as proposed by Proaño and Lojak (2020). Further, to keep the baseline model as simple as possible, it will be assumed that the economy's long-run equilibrium is stationary and deterministic, i.e. that it has no trending behavior either of a deterministic or a stochastic nature,[4] and that the price level is constant and normalized to $P_t = 1 \; \forall \, t$ for notational simplicity. Therefore, the potential (real) output is constant:

$$\mathbb{Y}_t = \mathbb{Y}_{t+1} = \mathbb{Y}. \tag{1}$$

### 2.1 Potential Output Estimation/Computation Process

As previously mentioned, the premise of this paper is that the actual potential output $\mathbb{Y}$ cannot be directly observed (as in the real world), but has to be estimated/computed by the economic agents through statistical and/or theoretical methods.

[4]This simplifying assumption does not imply any loss of generality since the end-point bias problem of the methods like the HP filter does not depend on the order of integration of the filtered series. This, of course, poses a strong restriction since, especially for longer time horizons, it can be assumed that agents would be able to learn that the potential output is constant. We relax this assumption in Section 6 where we allow for movements in the potential output due to weak hysteresis and show that this does not change the essence of our findings.

Against this background, the *estimated* potential output $\hat{\mathbb{Y}}_t$ is assumed in the following to be computed adaptively through

$$\hat{\mathbb{Y}}_t = \hat{\mathbb{Y}}_{t-1} \left( \frac{Y_{t-1}}{\hat{\mathbb{Y}}_{t-1}} \right)^{\beta_{\hat{y}}} . \tag{2}$$

According to (2), the past (observable) output $Y_{t-1}$ positively impacts the *estimated* potential output $\hat{\mathbb{Y}}_t$, in a similar manner as actual output influences the potential output estimation in standard filtering techniques.

Expanding and taking logarithms yields the evolution of the gap (in percent) between the estimated potential output $\hat{\mathbb{Y}}_t$ and the true potential output $\mathbb{Y}$

$$\begin{aligned}
\ln\left(\hat{\mathbb{Y}}_t \frac{\mathbb{Y}}{\mathbb{Y}}\right) &= \ln\left(\hat{\mathbb{Y}}_{t-1} \frac{\mathbb{Y}}{\mathbb{Y}} \left( \frac{Y_{t-1}}{\hat{\mathbb{Y}}_{t-1}} \frac{\mathbb{Y}}{\mathbb{Y}} \right)^{\beta_{\hat{y}}}\right) \\
\tilde{\mathbb{y}}_t &= \tilde{\mathbb{y}}_{t-1} + \ln(\mathbb{Y}/\mathbb{Y}) + \beta_{\hat{y}}\left(\hat{y}_{t-1}\right) \\
\tilde{\mathbb{y}}_t &= \tilde{\mathbb{y}}_{t-1} + \beta_{\hat{y}}\left(y_{t-1} - \tilde{\mathbb{y}}_{t-1}\right) \\
\tilde{\mathbb{y}}_t &= (1-\beta_{\hat{y}})\tilde{\mathbb{y}}_{t-1} + \beta_{\hat{y}} y_{t-1},
\end{aligned} \tag{3}$$

where $\tilde{\mathbb{y}}_t = \ln(\hat{\mathbb{Y}}_t/\mathbb{Y})$ represents the (log) ratio between the estimated and the true potential output (a ratio that cannot be observed by the agents in the model),

$$\hat{y}_t = \ln(Y_t/\hat{\mathbb{Y}}_t) = y_t - \tilde{\mathbb{y}}_t \tag{4}$$

the estimated output gap (i.e. the log ratio between the actual output and the estimated potential output), and $y_t = \ln(Y_t/\mathbb{Y})$ the actual (unobservable) output gap. As it will become clear below, the (unobservable) ratio $\tilde{\mathbb{y}}_t$ will affect the government's fiscal stance in a non-negligible manner.

### 2.2 The Government Sector

The government is assumed to finance its expenditures $G_t$ and the interest on outstanding debt $(1 + r_t)B_{t-1}$ through tax revenues $T_t$ as well as through the issuance of new bonds solely. More specifically, government expenditures, expressed via their long-run level $\mathbb{G}$ are assumed to be determined as follows:

$$G_t = \mathbb{G} \left( \frac{Y_{t-1}}{\hat{\mathbb{Y}}_{t-1}} \right)^{-\phi_{gy}} \left( \frac{B_{t-1}}{Y_{t-1}} \Big/ \theta_B^T \right)^{-\phi_{gb}} \tag{5}$$

where $\theta_B^T$ denotes the long-run target debt-to-GDP ratio and $\frac{B_{t-1}}{Y_{t-1}}$ denotes actual debt-to-GDP ratio.

Expanding (5) by $\mathbb{Y}/\mathbb{Y}$ and $\mathbb{B}/\mathbb{B}$ and taking logarithms yields

$$\begin{aligned}
\ln\left(\frac{G_t}{\mathbb{G}}\right) &= -\phi_{gy}\hat{y}_{t-1} - \phi_{gb}\left(\ln\left(\frac{B_{t-1}}{\mathbb{B}}\right) - \ln\left(\frac{Y_{t-1}}{\mathbb{B}}\right) - \ln\left(\frac{\mathbb{B}}{\mathbb{Y}}\right)\right) \\
g_t &= -\phi_{gy}(\overbrace{y_{t-1} - \tilde{\mathbb{y}}_{t-1}}^{\hat{y}_{t-1}}) - \phi_{gb}(b_{t-1} - \overbrace{\ln\left(\frac{Y_{t-1}}{\mathbb{Y}}\right)}^{y_{t-1}}) \\
&= (\phi_{gb} - \phi_{gy})y_{t-1} - \phi_{gb}b_{t-1} + \phi_{gy}\tilde{\mathbb{y}}_{t-1}. \qquad (6)
\end{aligned}$$

where $g_t = \ln(G_t/\mathbb{G})$, $b_t = \ln(B_t/\mathbb{B})$ and $\ln(\theta_B^T) = \ln(\mathbb{B}/\mathbb{Y})$ by assumption.

As clearly shown in equation (6), the unobservability of the actual potential output $\mathbb{Y}$ impacts the adequateness of government spending through the biased response to the economy's actual cyclical situation. Further, note that the economy's agents will only observe the sum of the two terms $y_{t-1} - \tilde{\mathbb{y}}_{t-1}$, namely $\hat{y}_{t-1}$ (see (4)).

Regarding taxation, lump-sum taxes are assumed to be set as a function of the estimated output gap in the previous period, i.e.

$$T_t = \mathbb{T}\left(\frac{Y_{t-1}}{\hat{\mathbb{Y}}_{t-1}}\right)^{\phi_{\tau y}}. \qquad (7)$$

In the case where $Y_{t-1} = \hat{\mathbb{Y}}_{t-1}$, i.e. when a zero output gap was estimated, $T_t = \mathbb{T}$, its long-run value. Otherwise, a procyclical tax policy is assumed that consolidates (sets higher taxes) in estimated boom phases and lowers taxes in estimated bust periods, as e.g. in Proaño and Lojak (2020, 2021). Dividing by $\mathbb{T}$ and taking logarithms yields

$$\tau_t \equiv \ln\left(\frac{T_t}{\mathbb{T}}\right) = \phi_{\tau y}(\overbrace{y_{t-1} - \tilde{\mathbb{y}}_{t-1}}^{\hat{y}_{t-1}}). \qquad (8)$$

Under the assumption of a constant price level (normalized to $P_t = 1\ \forall\ t$) and no money issuance, the evolution of government debt in real terms is determined by the governments' flow real budget constraint (GBC), namely

$$B_t = (1 + r_t)B_{t-1} + G_t - T_t. \qquad (9)$$

where $r_t$ is the nominal interest rate set at the end of $t-1$ and to be paid at $t$, which is assumed to be endogenously determined, as discussed below.

### 2.3 Private Consumption

The modeling of private consumption is purposely kept as simple as possible in order to highlight the fiscal policy transmission channel of potential output uncertainty.

$$C_t = \mathbb{C}\left(\frac{Y_{t-1}}{\hat{\mathbb{Y}}_{t-1}}\right)^{\alpha_y}\left(\frac{1+r_t}{1+\mathbb{r}}\right)^{-\alpha_r}\exp(\varepsilon_t^c) \tag{10}$$

By dividing both sides by $\mathbb{C}$ and taking logarithms we obtain

$$\begin{aligned}\ln\left(\frac{C_t}{\mathbb{C}}\right) &= \alpha_y \ln\left(\frac{Y_{t-1}}{\hat{\mathbb{Y}}_{t-1}}\right) - \alpha_r \ln\left(\frac{1+r_t}{1+\mathbb{r}}\right) + \varepsilon_t^c \\ c_t &= \alpha_y \hat{y}_{t-1} - \alpha_r(r_t - \mathbb{r}) + \varepsilon_t^c. \end{aligned} \tag{11}$$

Accordingly, private consumption fluctuates around its long-run value $\mathbb{C}$ due to deviations of $Y_t$ from the estimated output level $\hat{\mathbb{Y}}_t$, deviations of the interest rate $r_t$ from the steady state real interest rate $\mathbb{r}$ and stochstic AR(1)-shocks.[5]

### 2.4 Sovereign Risk Premium Determination

As in Proaño and Lojak (2020, 2021), and also following Adrian et al. (2010), the perceived sovereign risk at time $t$ is specified as a linear combination of various macroeconomic fundamentals. More specifically, the log risk premium is

$$\begin{aligned}\zeta_t &= -\xi_y \hat{y}_{t-1} + \xi_b\left(\ln\left(\frac{B_{t-1}}{Y_{t-1}}\right) - \ln(\theta_B^T)\right) + \varepsilon_t^\zeta \\ &= -\xi_y \hat{y}_{t-1} + \xi_b\left(\ln\left(\frac{B_{t-1}}{\mathbb{B}}\right) - \ln\left(\frac{Y_{t-1}\cdot\mathbb{Y}}{\mathbb{B}\cdot\mathbb{Y}}\right) - \ln(\theta_B^T)\right) + \varepsilon_t^\zeta \\ &= -\xi_y\left(y_{t-1} - \tilde{\mathbb{y}}_{t-1}\right) + \xi_b\left(b_{t-1} - y_{t-1} + \ln(\theta_B^T) - \ln(\theta_B^T)\right) + \varepsilon_t^\zeta \\ &= -\left(\xi_y + \xi_b\right) y_{t-1} + \xi_b b_{t-1} + \xi_y \tilde{\mathbb{y}}_{t-1} + \varepsilon_t^\zeta, \end{aligned} \tag{12}$$

where it is assumed that financial market participants take also into account the cyclically-adjusted debt-to–GDP ratio in concordance with the expenditure rule (5).

According to eq. (12), the perceived sovereign risk is determined by the economy's (estimated or perceived) current output gap, the percent deviation of the cyclically-adjusted government debt-to-(potential-)GDP ratio to $\theta_B^T$ at $t-1$, and by $\varepsilon_t^\zeta$, an AR(1) stochastic shock.

[5] As we study a zero-inflation environment in this paper, the nominal and the real interest rate always coincide. In future extensions of the model, this strong assumption will be relaxed to investigate the role of monetary policy.

The (nominal and real) one-period interest rate on government bonds is thus given by

$$\begin{aligned} 1 + r_t &= (1 + \mathbb{r}) \cdot \exp(\zeta_t) \\ &= (1 + \mathbb{r}) \cdot \exp(-(\xi_y + \xi_b)\, y_{t-1} + \xi_b b_{t-1} + \xi_y \tilde{\mathbb{y}}_{t-1} + \varepsilon_t^{\zeta}). \end{aligned} \tag{13}$$

## 3 Local Stability Analysis

Since we abstract from aggregate investment and international trade, aggregate demand (and output) $Y_t$ consists only of private consumption $C_t$ and government spending $G_t$. For analytical tractability, we use the following approximation in the following:

$$Y_t = C_t + G_t \quad \left( \approx \left(\frac{C_t}{\mathbb{C}}\right)^{\theta_C} \cdot \left(\frac{G_t}{\mathbb{G}}\right)^{\theta_G} \cdot \mathbb{Y} \right), \tag{14}$$

where $G_t$ is determined by (5) and $\theta_C = \frac{\mathbb{C}}{\mathbb{Y}}$ and $\theta_G = \frac{\mathbb{G}}{\mathbb{Y}}$. Further, we abstract from uncertainty in the risk premium equation (12), and assume that private consumption always stays at its long-run steady state level, i.e. $C_t = \mathbb{C}$ to focus on the fiscal policy channel. Under these assumptions, and when expressed in terms of observable log deviations from the true (unobservable) potential output level and the corresponding long-term components together with (14), (6), (13) and (9) (after a loglinearization around $\mathbb{r} = 0$),[6] this simplified model (with the output approximation as above) can be represented in terms of three endogenous variables $y_t$, $b_t$, and $\tilde{\mathbb{y}}_t$ as[7]

$$\begin{aligned} y_t &= \theta_C c_t + \theta_G g_t \;=\; \theta_C \cdot 0 + \theta_G \left((\phi_{gb} - \phi_{gy}) y_{t-1} - \phi_{gb} b_{t-1} + \phi_{gy} \tilde{\mathbb{y}}_{t-1}\right) && (15) \\ b_t &= (r_t - \mathbb{r}) + b_{t-1} + \frac{\theta_G}{\theta_B^T}\left((\phi_{gb} - \phi_{gy} - \phi_{\tau y}) y_{t-1} - \phi_{gb} b_{t-1} + (\phi_{gy} + \phi_{\tau y}) \tilde{\mathbb{y}}_{t-1}\right) && (16) \\ \tilde{\mathbb{y}}_t &= (1 - \beta_{\hat{y}}) \tilde{\mathbb{y}}_{t-1} + \beta_{\hat{y}} y_{t-1} && (17) \end{aligned}$$

where

$$r_t \approx \mathbb{r} + \zeta_t = \mathbb{r} - (\xi_y + \xi_b)\, y_{t-1} + \xi_b b_{t-1} + \varepsilon_t^{\zeta}.$$

Following Flaschel et al. (2008) and Flaschel and Proaño (2009), the continuous-time representation of the model will be considered to analyze its local stability properties. Accordingly, the lag of the

[6] Taking logarithms on both sides of (9) yields

$$\ln(B_t) = \ln\left((1 + r_t) B_{t-1} + G_t - T_t\right)$$

A first-order Taylor series expansion with respect to $r$ around the steady state ($\mathbb{r} = 0$, $B_t = \mathbb{B}$, $G_t = \mathbb{G}$, $T_t = \mathbb{T}$ and $\mathbb{G} = \mathbb{T}$) on both sides of the above equation delivers

$$\begin{aligned} \ln(\mathbb{B}) + \frac{1}{\mathbb{B}}(B_t - \mathbb{B}) &= \ln\left((\mathbb{B}) + (r_t - \mathbb{r}) + \frac{1}{\mathbb{B}}(B_{t-1} - \mathbb{B}) + \frac{1}{\mathbb{B}}(G_t - \mathbb{G}) - \frac{1}{\mathbb{B}}(T_t - \mathbb{T})\right. \\ \frac{(B_t - \mathbb{B})}{\mathbb{B}} &= (r_t - \mathbb{r}) + \frac{(B_{t-1} - \mathbb{B})}{\mathbb{B}} + \frac{(G_t - \mathbb{G})}{\mathbb{G}}\frac{\mathbb{G}}{\mathbb{B}} - \frac{(T_t - \mathbb{T})}{\mathbb{T}}\frac{\mathbb{T}}{\mathbb{B}} \\ b_t &= (r_t - \mathbb{r}) + b_{t-1} + g_t \frac{\mathbb{G}}{\mathbb{Y}}\frac{\mathbb{Y}}{\mathbb{B}} - \tau_t \frac{\mathbb{T}}{\mathbb{Y}}\frac{\mathbb{Y}}{\mathbb{B}} \\ &= (r_t - \mathbb{r}) + b_{t-1} + \frac{\theta_G}{\theta_B^T}(g_t - \tau_t) \end{aligned}$$

with $\frac{(B_{t-1} - \mathbb{B})}{\mathbb{B}} \approx \ln(B_{t-1}/\mathbb{B}) = b_{t-1}$, $\frac{(B_t - \mathbb{B})}{\mathbb{B}} \approx \ln(B_t/\mathbb{B}) = b_t$, $\frac{(G_t - \mathbb{G})}{\mathbb{G}} \approx \ln(G_t/\mathbb{G}) = g_t$ and $\frac{(T_t - \mathbb{T})}{\mathbb{T}} \approx \ln(T_t/\mathbb{T}) = \tau_t$; $g_t$ and $\tau_t$ being given by (6) and (8), respectively. Inserting these expressions yields finally

$$\begin{aligned} b_t &= (r_t - \mathbb{r}) + b_{t-1} + \frac{\theta_G}{\theta_B^T}\left((\phi_{gb} - \phi_{gy}) y_{t-1} - \phi_{gb} b_{t-1} + \phi_{gy} \tilde{\mathbb{y}}_{t-1} - \phi_{\tau y}(y_{t-1} - \tilde{\mathbb{y}}_{t-1})\right) \\ &= (r_t - \mathbb{r}) + b_{t-1} + \frac{\theta_G}{\theta_B^T}\left((\phi_{gb} - \phi_{gy} - \phi_{\tau y}) y_{t-1} - \phi_{gb} b_{t-1} + (\phi_{gy} + \phi_{\tau y}) \tilde{\mathbb{y}}_{t-1}\right). \end{aligned}$$

[7] Given the fact that the present framework abstracts from investment dynamics, price and wage inflation and thus from the study of income distribution shifts, it could be considered closer to a supply-driven DSGE model than a post-Keynesian framework. This view, however, is misleading as the present framework does not contain technological shocks (a key feature of Real-Business Cycle-based DSGE models), and agents are boundedly rational, in contrast to the full-information-rational-expectations (FIRE) paradigm of DSGE models.

endogenous variable is subtracted from each respective equation and the three-equation system is expressed in terms of a flexible time-length $h$, i.e.

$$
\begin{aligned}
\frac{y_t - y_{t-h}}{h} &= \theta_G(\phi_{gb} - \phi_{gy} - \frac{1}{\theta_G})y_{t-h} - \theta_G\phi_{gb}b_{t-h} + \theta_G\phi_{gy}\tilde{\mathrm{y}}_{t-h} \\
\frac{b_t - b_{t-h}}{h} &= -\left(\xi_y + \xi_b\right)y_{t-1} + \xi_b b_{t-1} + \varepsilon_t^{\zeta} \\
&\quad + \frac{\theta_G}{\theta_B^T}\left((\phi_{gb} - \phi_{gy} - \phi_{\tau y})y_{t-h} - \phi_{gb}b_{t-h} + (\phi_{gy} + \phi_{\tau y})\tilde{\mathrm{y}}_{t-h}\right) \\
\frac{\tilde{\mathrm{y}}_t - \tilde{\mathrm{y}}_{t-h}}{h} &= -\beta_{\hat{y}}\tilde{\mathrm{y}}_{t-h} + \beta_{\hat{y}}y_{t-h}.
\end{aligned}
$$

Letting $h \to 0$ yields

$$\dot{y} = \theta_G\left(\phi_{gb} - \phi_{gy} - \frac{1}{\theta_G}\right)y - \theta_G\phi_{gb}b + \theta_G\phi_{gy}\tilde{\mathrm{y}} \tag{18}$$

$$\dot{b} = -\left(\xi_y + \xi_b - (\phi_{gb} - \phi_{gy} - \phi_{\tau y})\frac{\theta_G}{\theta_B^T}\right)y + \left(\xi_b - \phi_{gb}\frac{\theta_G}{\theta_B^T}\right)b + \left((\phi_{gy} + \phi_{\tau y})\frac{\theta_G}{\theta_B^T}\right)\tilde{\mathrm{y}} \tag{19}$$

$$\dot{\tilde{\mathrm{y}}} = \beta_{\hat{y}}(y - \tilde{y}). \tag{20}$$

The Jacobian matrix of this three-dimensional differential equation system is then given by

$$J = \begin{pmatrix} \frac{\partial \dot{y}}{\partial y} & \frac{\partial \dot{y}}{\partial b} & \frac{\partial \dot{y}}{\partial \tilde{\mathrm{y}}} \\ \frac{\partial \dot{b}}{\partial y} & \frac{\partial \dot{b}}{\partial b} & \frac{\partial \dot{b}}{\partial \tilde{\mathrm{y}}} \\ \frac{\partial \dot{\tilde{\mathrm{y}}}}{\partial y} & \frac{\partial \dot{\tilde{\mathrm{y}}}}{\partial b} & \frac{\partial \dot{\tilde{\mathrm{y}}}}{\partial \tilde{\mathrm{y}}} \end{pmatrix} = \begin{pmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & J_{22} & J_{23} \\ J_{31} & J_{32} & J_{33} \end{pmatrix}$$

with

$$
\begin{aligned}
J_{11} &= \theta_G(\phi_{gb} - \phi_{gy} - \frac{1}{\theta_G}) & J_{12} &= -\theta_G\phi_{gb} & J_{13} &= \theta_G\phi_{gy} \\
J_{21} &= -\left(\xi_y + \xi_b - (\phi_{gb} - \phi_{gy} - \phi_{\tau y})\frac{\theta_G}{\theta_B^T}\right) & J_{22} &= \left(\xi_b - \phi_{gb}\frac{\theta_G}{\theta_B^T}\right) & J_{23} &= (\phi_{gy} + \phi_{\tau y})\frac{\theta_G}{\theta_B^T} \\
J_{31} &= \beta_{\hat{y}} & J_{32} &= 0 & J_{33} &= -\beta_{\hat{y}}.
\end{aligned}
$$

The principal minors of order 2 of this matrix are given by the following determinants:

$$J_1 = \begin{vmatrix} J_{22} & J_{23} \\ J_{32} & J_{33} \end{vmatrix}, \quad J_2 = \begin{vmatrix} J_{11} & J_{13} \\ J_{31} & J_{33} \end{vmatrix}, \quad J_3 = \begin{vmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{vmatrix}.$$

Let us denote by $a_1 = -\mathrm{tr}(J)$, $a_2 = J_1 + J_2 + J_3$ and by $a_3 = -\det(J)$. According to the Routh-Hurwitz conditions, the eigenvalues of the matrix $J$ have all negative real parts iff

$$a_i > 0,\ i = 1, 2, 3 \quad \text{and} \quad a_1 a_2 - a_3 > 0.$$

Regarding $a_3$, we have

$$a_3 = -\det(J) = -\frac{\beta_{\hat{y}}\phi_{gb}\theta_B^T\theta_G\xi_y - \beta_{\hat{y}}\phi_{gb}\theta_G + \beta_{\hat{y}}\theta_B^T\xi_b}{\theta_B^T} > 0,$$

what holds if

$$\phi_{gb}\theta_G > \left(\frac{\theta_B^T\xi_b}{1-\theta_B^T\xi_y}\right).$$

The economic interpretation of this condition is straightforward: For given values of the debt-to-output ratio target $\theta_B^T$, a higher risk premium sensitivity to the government debt ratio or to the output gap (represented by $\xi_b$ and $\xi_y$) require higher values of $\phi_{gb}$, i.e. a stricter debt stabilization policy, if government debt- and macroeconomic stability is to be guaranteed.

Regarding $a_1$, and assuming that $a_3 > 0$ holds, we can write

$$a_1 = -\mathrm{tr}(J) = \beta_{\hat{y}} + \phi_{gb}\frac{\theta_G}{\theta_B^T} - \theta_G\left(\phi_{gb} - \phi_{gy}\right) - \xi_b + 1 = 1 + \beta_{\hat{y}} + \phi_{gb}\theta_G\left(\frac{1-\theta_B^T}{\theta_B^T}\right) + \phi_{gy} - \xi_b > 0$$

so $a_1 > 0$ holds if

$$1 + \beta_{\hat{y}} + \phi_{gb}\theta_G\left(\frac{1-\theta_B^T}{\theta_B^T}\right) + \phi_{gy} > \xi_b$$

which certainly holds for a meaningful calibration of the model if $\xi_b$ is sufficiently low.

Finally, regarding $a_2 = J_1 + J_2 + J_3$, we have, after conveniently rearranging,

$$\begin{aligned}
J_1 &= \beta_{\hat{y}}\phi_{gb}\frac{\theta_G}{\theta_B^T} - \beta_{\hat{y}}\xi_b \\
J_2 &= \beta_{\hat{y}}(1-\phi_{gb}\theta_G) \\
J_3 &= \frac{-\phi_{gb}\phi_{\tau y}\theta_G^2 - \phi_{gb}\theta_B^T\theta_G\xi_y + \phi_{gb}\theta_G - \phi_{gy}\theta_B^T\theta_G\xi_b - \theta_B^T\xi_b}{\theta_B^T}
\end{aligned}$$

we get

$$a_2 = \phi_{gb}\frac{\theta_G}{\theta_B^T}\left[\beta_{\hat{y}}\left(1-\theta_B^T\right) + 1 - \phi_{\tau y}\theta_G - \theta_B^T\xi_y\right] + \beta_{\hat{y}} > \xi_b(1 + \phi_{gy}\theta_G + \beta_{\hat{y}})$$

While higher values of $\xi_b$ are destabilizing (as well as higher values of $\phi_{gy}$ when $\xi_b$ is high already), higher values of $\beta_{\hat{y}}$ seem to have an ambiguous role, both relaxing the above condition through the right-hand-side terms, as well as making it more binding through the left hand-side term that is multiplied with $\xi_b$.

Given the complexity of the analytical expression for $a_2 > 0$ and $a_1a_2 - a_3 > 0$, we confirmed numerically using the values reported in Table 1 that those expressions are indeed positive for the calibration used in the simulation part. Furthermore in order to highlight the importance for stability of certain parameters reference is made to figure 1 where the stability of the system with regard to a sufficient government debt stabilization in response to the destabilizing financial market reactions is evaluated. As already described above, a sufficient reaction of government spending concerning its debt stabilization (expressed via the parameter $\phi_{gb}$) is necessary in response towards the assumed bond vigilantes (which is steered by the parameters $\xi_y$ and $\xi_b$). As visible in figure 1 the sufficient reaction depends on the the response of the financial markets towards the output gap ($\xi_y$) but far more decisively on the reaction towards the government indebtedness ($\xi_b$).

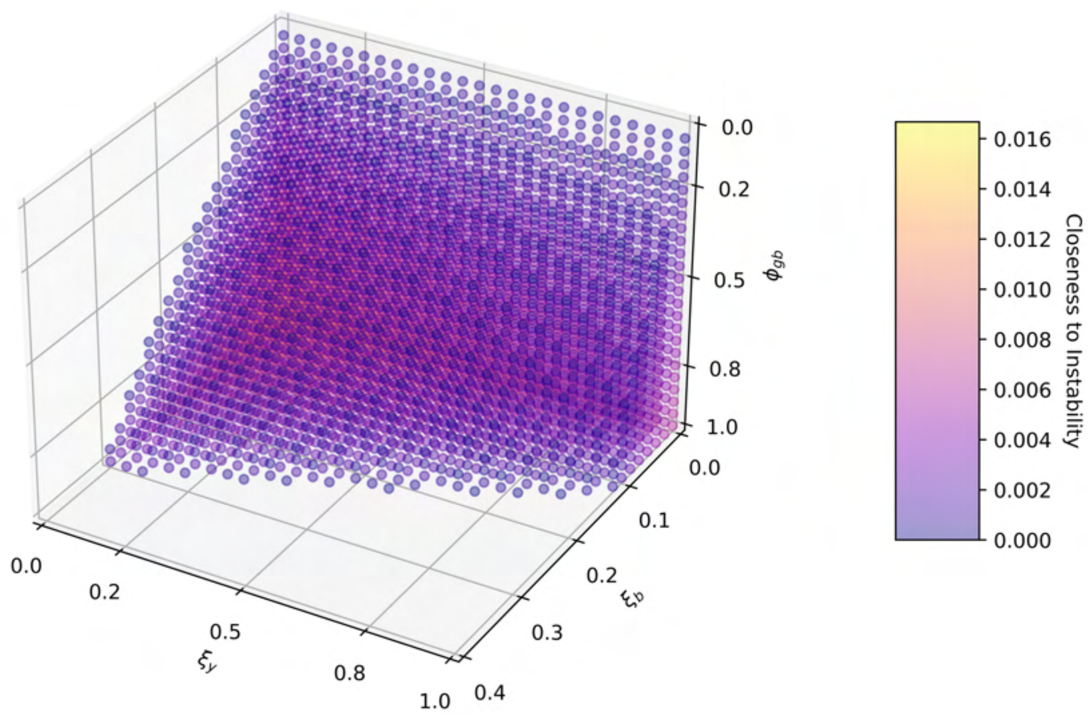


Figure 1: Each dot represents a stable parameter constellation of $\phi_{gb}$ in response to certain values of $\xi_y$ and $\xi_b$ (all other parameters as in Table 1). The closeness to instability is measured as smallest acceptance of the Routh-Hurwitz conditions described above.

In summary, the local stability analysis of this section establishes a direct positive connection between the sensitivity of the risk premium with respect to the government indebtedness level (measured as the ratio of government debt to output) and the debt stabilization coefficient in the government spending rule which in fact determined the local stability of the system.[8] Obviously, when the endogenous reaction of private consumption would be further incorporated, the restriction regarding

[8] This condition can obviously be related to the well-known condition for debt sustainability that requires that the real interest rate on debt should be lower than the growth rate of GDP, see e.g. Bohn (1998) and Schoder et al. (2013).

$\phi_{gb}$ would be even more binding. In other words, if markets charge a premium on new government debt when the debt to output ratio increases, the government needs to adjust government spending in line with $\theta_G\phi_{gb} > \frac{\xi_b\theta_B^T}{(1-\theta_B^T\xi_y)}$, if government indebtedness, and the overall macro-financial system (in this very simplified setup) is not to become (locally) unstable.[9] As the coefficient $\xi_b$ is quite likely to be endogenous and determined not only by economic but also by political and even geopolitical factors in the real world, this result highlights the importance of high credibility of the government among financial market participants for the government's fiscal space, at least in the short run. We will explore this issue in Section 5 further.

Having discussed the conditions for local stability of the model's steady state, the model's dynamic reaction to an exogenous consumption shock will be discussed in the next section to highlight the model's transmission mechanisms.

## 4 Dynamic Adjustments of the Baseline Model

For the following simulation exercises we assume a balanced government budget in the long-run, as it is standard in the literature, see e.g. Beetsma and Jensen (2005). Further, the cyclical elasticity of government expenditures and tax revenues is set equal to $\phi_{gy} = 0.80$ and $\phi_{\tau y} = 0.12$ to assure the stability of the following model simulations.[10] For the simulation of the baseline scenario (figure 2), we set the elasticity of the cyclical government expenditures to the debt-to-(potential-)GDP to $\phi_{gb} = 0$ (and $\xi_b = 0$) illustrating the situation in which fiscal spending is not bound by debt rules.

Table 1: Parameter Values for Baseline Scenario

| Parameter | Symbol | Value |
|---|---|---|
| Adjustment parameter of potential output estimation | $\beta_{\hat{y}}$ | 0.05 |
| Interest rate elasticity of consumption | $\alpha_r$ | 0.5 |
| Past output gap elasticity of consumption | $\alpha_y$ | 0.8 |
| Long-run consumption/output ratio | $\mathbb{C}$ | 0.8 |
| Long-run government expenditures/output ratio | $\mathbb{G}$ | 0.2 |
| Long-run taxes/output ratio | $\mathbb{T}$ | 0.2 |
| Long-run government debt/output ratio | $\mathbb{B}$ | 0.6 |
| Target government debt/output ratio | $\theta_B^T$ | 0.6 |
| Long-run (real) interest rate | $\mathbb{r}$ | 0.0 |
| Output gap elasticity of cyclical government expenditures | $\phi_{gy}$ | 0.8 |
| Debt elasticity of cyclical government expenditures | $\phi_{gb}$ | 0 (0.2) |
| Output gap elasticity of cyclical tax revenues | $\phi_{\tau y}$ | 0.12 |
| Output gap coefficient in risk premium | $\xi_y$ | 0.05 |
| Debt/GDP ratio coefficient in risk premium | $\xi_b$ | 0 (0.00744) |
| Autocorrelation coefficients | $\rho_{\varepsilon^c}/\rho_{\varepsilon^\zeta}$ | 0.9 / 0.2 |
| Standard deviations of exogenous shocks | $\sigma_c/\sigma_\zeta$ | 0.01 |

[9] Note that given the linear nature of the continuous-time approximation of the model, local and asymptotic stability are equivalent concepts. In the nonlinear representation of the model, these two concepts are not equivalent, though.

[10] Mayer and Stähler (2013), set a total cyclical elasticity of the structural budget deficit equal to 0.32. We set a higher value especially of $\phi_{gy}$ that implies almost a twice time higher cyclical elasticity to highlight the working of the fiscal policy channel in our model.

With respect to the reaction parameters in the market perceptions of sovereign risk, given the lack of empirical estimates, we set it arbitrarily to $\xi_y = 0.05$. The value of the investors sensitivity to the debt-GDP ratio corresponds to $\xi_b = 0$ to initially illustrate the case where investors disregard this variable.[11] Table 1 summarizes all these parameter values.

Finally, the dynamics of the stochastic shocks of the system are given through AR(1)-processes in logs. For instance, the stochastic shock process $\varepsilon_t^c$ impacting (the otherwise constant) private consumption is given by

$$\varepsilon_t^c = \rho_{\varepsilon^c}\varepsilon_{t-1}^c + e_t^c. \tag{21}$$

where $e_t^c \sim WN(0, \sigma_c^2)$.

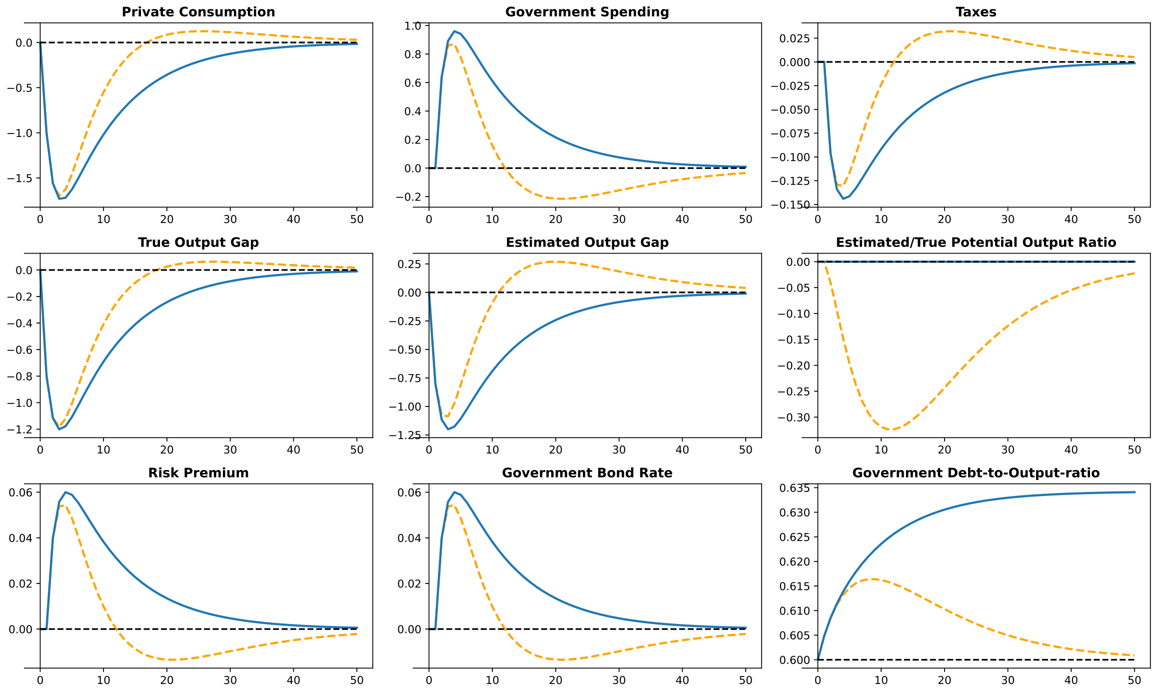


Figure 2: Dynamic adjustments of the simplified model under a known true potential output (continuous line) and an estimated potential output (dashed line) following a negative AR(1) shock to private consumption by one-percent using the parameter values reported in Table 1.

Figure 2 illustrates the dynamic adjustments of the simplified model following an autocorrelated negative consumption shock. As it can be observed, the negative consumption shock leads to a reduction in aggregate demand and output which, given the exogenous steady state value $\mathbb{Y}$, would translate to a negative output gap of the same size if government spending was unchanged. However,

[11]We relax this assumption later and use the estimates provided by De Grauwe and Ji (2013).

since $\phi_{gy}$ and $\phi_{\tau y}$ are positive, the initial negative demand shock is alleviated to some extent by an expansion in government spending and the reduction of taxes.

The reduction in economic activity leads, through equation (2), to a downward revision in the estimated/perceived potential output $\hat{\mathbb{Y}}_t$, and thus to a lower estimated-to-true potential output ratio $\tilde{\mathbb{y}}_t = \ln(\hat{\mathbb{Y}}_t/\mathbb{Y}_t)$, as illustrated in the second row/third column graph in figure 2. This mechanism has important consequences in the subsequent periods for the conduct of fiscal policy and the overall evolution of government debt, as further illustrated in figure 2. Since a reduction in the actual output $Y_t$ leads to a reduction of the estimated or perceived potential output $\hat{\mathbb{Y}}_t$, the perceived output gap is smaller (less negative) or even has the opposite sign compared to the true (unobservable) output gap (see the second row, second column graph in figure 2). This procyclical mechanism leads to a decreased counter-cyclicality in government spending and taxes, which translates to a quite differentiated evolution of the government debt-to-output ratio: In the case where every agent knows the true potential output (and thus the present output gap) the initial counter-cyclical reaction of government spending and taxes leads to a permanent increase in the government debt-to-output ratio (which does not need to be reversed given the lack of an endogenous debt-stabilization term $\phi_{gb} = 0.0$ and the absence of bond vigilantes $\xi_b = 0.0$). Under output gap uncertainty (OGU), government spending falls below its initial level and taxes rise above it in the medium term, leading to an overall fiscal consolidation which returns the government debt-to-output ratio to almost its initial level after 50 quarters. These developments are further exacerbated by the evolution of the government bond rate, which is always above its initial value when no OGU is present but goes below it in the presence of OGU after some periods.

It is worth noting that even if this fiscal consolidation occurs fully unintendedly (as $\phi_{gb} = 0.0$) and almost "unnecessarily", given the absence of bond vigilantes and the corresponding reaction of the sovereign risk premium ($\xi_b = 0.0$), and that there was "too little" reaction of government spending to the initial shock, the actually realized path of the output gap is less negative in the OGU case (as visible in the second row/first column of figure 2). This at first glance confusing result can be explained by the fact that in the setting of figure 2 not only the fiscal spending is subject to OGU but also the private consumption and the financial markets (see equations (10) and (12)). Due to the underestimated output gap by the private sector and within the risk premia determination, consumption is reduced less (or even increased) than in the scenario without uncertainty. Also the reaction of the financial markets towards the negative private consumption shock is dampened by the occurrence of OGU so that the penalty of the risk premia is much weaker when financial markets are constrained in their assessment of the output gap. This case of "ignorance is bliss" outweighs and therefore blurs the negative effect of government spending adjusted to the misspecified output gap.

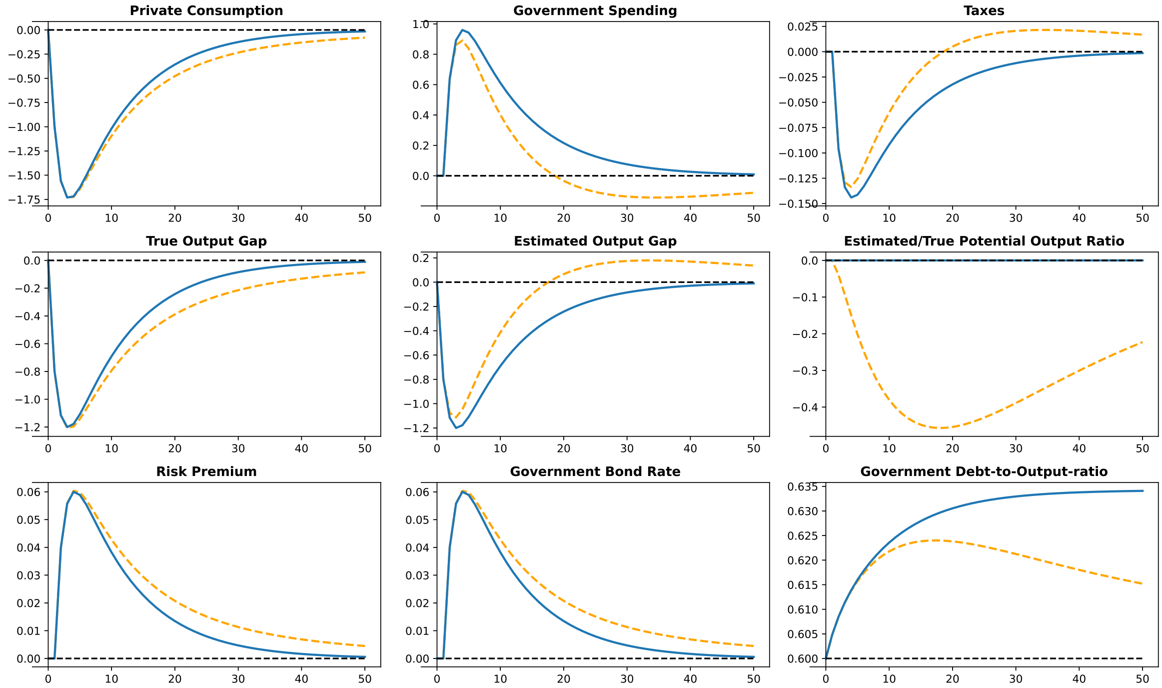


Figure 2 a.): Same simulation as in figure 2 but with consumption and risk premia determination depending on the actual potential output $\mathbb{Y}$ instead of $\hat{\mathbb{Y}}$ (see equations (10) and (12)).

Figure 2 a.) illustrates the same scenario, however with only the fiscal sector (and thus government spending and taxes) being subject to OGU (and not private consumption anymore). Under this assumption more clear dynamics emerge in which an observable actual output gap in the government spending and taxation decisions achieves better results in terms of macroeconomic stabilization. Since this paper wants to shed light on the macroeconomic consequences of a misspecified potential output used in fiscal policy decisions, we will assume for the following simulations that the financial markets and private consumption are perfectly informed and thus react to the actual output gap instead to the estimated one.

Figure 3 illustrates the effects of an increasing sensitivity of the sovereign risk premium with respect to the debt-to-output ratio represented by higher values of the parameter $\xi_b$ on the key variables of the model. As it can be clearly observed, for higher values of $\xi_b$, a destabilizing feedback loop sets in after a negative private consumption shock: Given the counter-cyclical response of government spending and taxes, the government debt-to-output ratio increases above its target value, leading to higher risk premia and thus, to an even higher debt-to-output ratio. This may not have significant consequences for output and consumption as long as these risk premium increases are not too big and government debt is thus not too excessive, as demonstrated by the previous local stability analysis. However, when

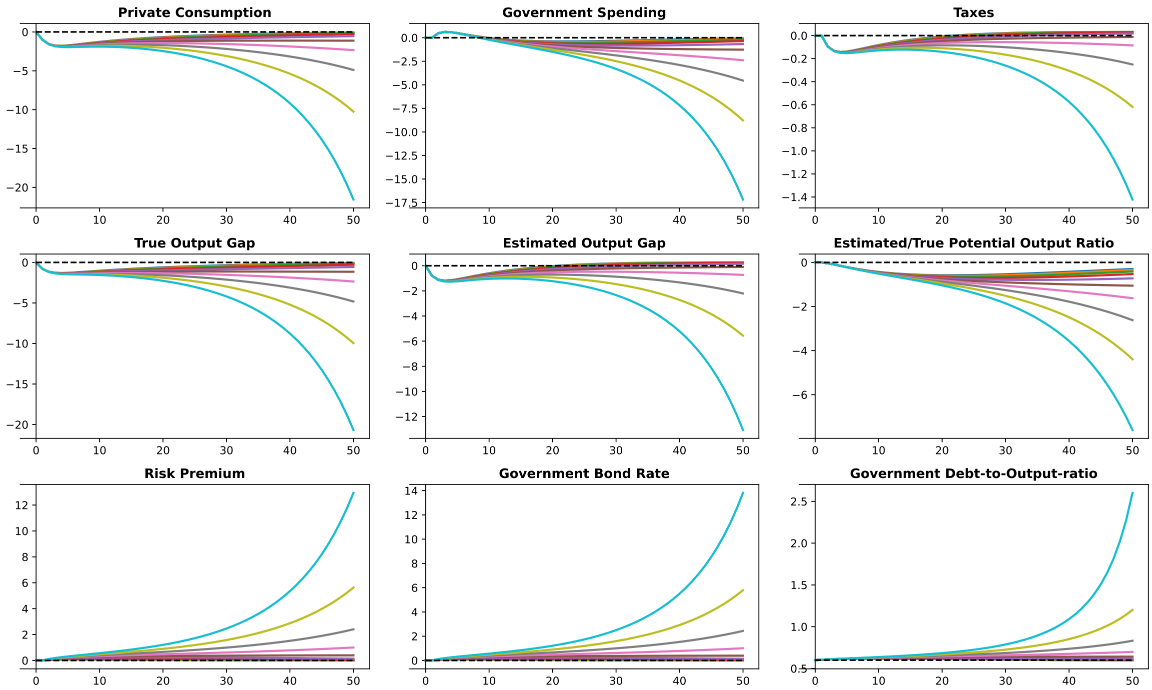


Figure 3: Dynamic adjustments of the baseline model under an estimated potential output following a negative AR(1) shock to private consumption by one-percent using the parameter values reported in Table 1 for increasing values of $\xi_b \in [0, 0.1]$ and $\phi_{gb} = 0.2$.

the debt-to-output ratio increases excessively, and government spending reacts negatively to such a development ($\phi_{gb} > 0$), the result is an even stronger fiscal austerity regime which reduces economic activity long-lastingly, even in this very simplified framework. Indeed, for $\phi_{gb} = 0$, even explosive dynamics of the government debt-to-output ratio would not affect the macroeconomic sphere if the government is able to roll out its debt even at high interest rates, leaving spending unchanged.

By contrast, figure 4 illustrates the impact of the adaptive mechanism parameter $\beta_{\hat{y}}$ in the estimation of the potential output, see equations (2) and (3), for the dynamics of the model. As it can be clearly observed, following a negative aggregate demand shock and the corresponding decrease in aggregate output $Y_t$, higher values of $\beta_{\hat{y}}$ translate into a lower estimated potential output $\hat{\mathbb{Y}}_t$ and thus to a lower ratio $\tilde{\mathrm{y}}_t = \ln(\hat{\mathbb{Y}}_t/\mathbb{Y})$, and a smaller estimated output gap $\hat{y}_t = \ln(Y_t/\hat{\mathbb{Y}}_t)$. In line with the analytical results concerning the local stability conditions of the continuous-time representation of the model, higher values of $\beta_{\hat{y}}$ do not lead to instability but, as can be seen, to increased macroeconomic volatility. It is however noteworthy that the government debt-to-output ratio converges to a higher level for $\beta_{\hat{y}} = 0.0$ (depicted by the blue line[12] in figure 4), while this new steady state for

[12]Note that for $\beta_{\hat{y}} = 0$ the displayed dynamics simulate the system without OGU since the adaptive estimation process in equation (2) is "switched-off".

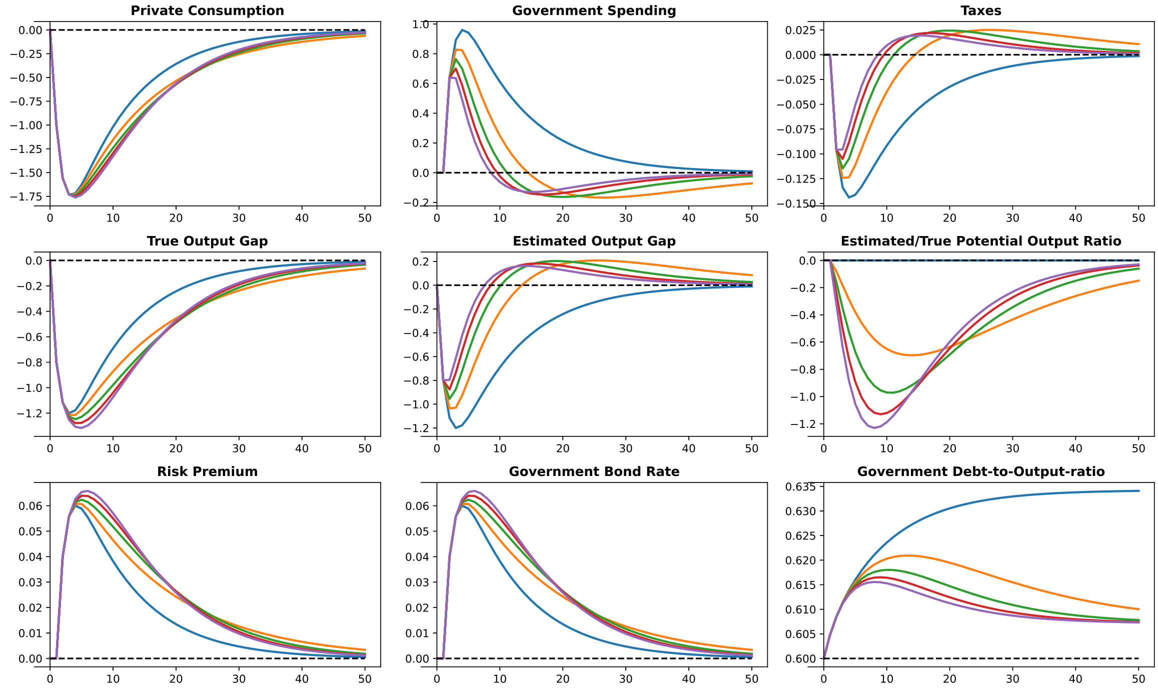


Figure 4: Dynamic adjustments of the baseline model following a negative consumption shock for increasing values of $\beta_{\hat{y}} \in [0, 0.5]$ (remaining values according to Table 1).

the government debt-to-output ratio is significantly lower for $\beta_{\hat{y}} > 0$. This is because if there is no uncertainty, countercyclical fiscal policy (higher government spending and lower taxes) is financed by taking on additional debt. However, as there is no incentive to reduce the additional debt burden again ($\phi_{gb} = 0$) and there are no bond vigilantes ($\xi_b = 0$), a new steady state debt-to-output ratio is feasible. In the case of $\beta_{\hat{y}} > 0$, there is a more timid reaction to the falsely anticipated output gap and later even fiscal consolidation, which leads to a lower level of debt-to-output ratio (compared to the no-uncertainty case) but at the cost of a weaker stabilization of the output gap.

## 5 The Model with Endogenous Government Credibility

In the following the model's dynamics are discussed for the case where the risk premia charged on government bonds by the financial market participants depends on the government's credibility regarding macroeconomic and debt stabilization. More specifically, let $\omega_t^C$ denote the fraction of the financial market participants that deem the government's fiscal policies as credible and worth supporting and $\omega_t^{NC} = 1 - \omega_t^C$ the counterpart fraction that believes the opposite. The fraction $\omega_t^C$

can be interpreted as an index of the government's credibility, along the lines of Proaño and Lojak (2020), and will be assumed to be determined by

$$\omega_t^C = \frac{\exp\left(y_{t-1}\right)}{\exp\left(y_{t-1}\right) + \exp\left(\mu_b \ln\left(\frac{B_{t-1}}{Y_{t-1}} \Big/ \theta_b^T\right)\right)} = \frac{\exp\left(y_{t-1}\right)}{\exp\left(y_{t-1}\right) + \exp\left(\mu_b(b_{t-1} - y_{t-1})\right)}. \tag{22}$$

with $\mu_b$ being a scaling parameter determining the relative importance of the debt-to-output ratio in the determination of $\omega_t$.[13] Assume e.g. that the government increases its spending, what leads to an increase of debt-to-GDP ratio and of the output gap of the same amount (e.g. 1%). If $\mu_b > 1$, this would lead to a *decrease* of $\omega_t^C$, as an expansion in the debt-to-GDP ratio would be considered by the bond vigilantes as *inefficient*, as it leads to an insufficient output gap increase. In contrast, if $0 < \mu_b < 1$, the government's credibility would be tied much more closely to the output gap development, as financial markets would care less about the debt-to-GDP ratio. One could therefore interpret the parameter $\mu_b$ as a measure of "hawkishness" of the bond vigilantes. Further, in the adverse case of a negative aggregate demand shock that would decrease the output gap, the government's credibility would only increase in case of a reduction in the debt-to-GDP ratio that is weighted sufficiently strong ($\mu_b >> 1$) by the bond vigilantes. In the real world, however, this may most likely depress output even more in the medium run (see Guajardo et al., 2014 for empirical evidence against the myth of expansionary fiscal austerity).

Let

$$A_t = \omega_t^{NC} - \omega_t^C, \quad A_t \in [-1, 1] \tag{23}$$

be an index that represents the "mood" in the financial system with respect to the government's fiscal stance. This "market mood" variable takes on the value of 0 at the steady state, i.e. in a balanced state of the economy where $y_t = 0$ and $B_t/Y_t = \theta_B^T$. A positive value reflects that the government's policy is not considered as credible by a majority of market participants, while a negative value indicates that the markets are rather optimistic about the overall conduct of fiscal policy.

Subsequently, the sovereign risk premium, previously determined according to (12), is assumed to be determined now by

$$\zeta_t = \xi_A A_t - \xi_y\, y_{t-1} + \xi_b\, b_{t-1} + (\xi_y - \xi_b)\, \tilde{y}_{t-1} + \varepsilon_t^\zeta. \tag{24}$$

with $\xi_A$ scaling to which extend the endogenous market mood will lower/increase the risk premium[14]. According to equation (24), the risk premium on the government's bonds will be, ceteris paribus,

[13] Here we assume that financial markets know for certain the true output gap intentionally in order to focus on the effects of OGU on fiscal policy, as explained in section 4.

[14] For the following, we will set $\xi_A = 0.05$ in order to simulate a risk premium benefit/disadvantage of 5% in extreme situations of the market mode ($A_t \in \{-1, 1\}$).

lower for a higher credibility, and vice versa and thus will depend in a nonlinear manner both on the perceived sovereign risk (which in our case is linked to macroeconomic fundamentals in a linear manner) and on the mood of the financial market participants. The risk premium is simply equal to the agents' sovereign risk perceptions when $A_t = 0$, i.e. when $\omega_t^C = \omega_t^{NC}$. Our specification reflects thus the nonlinear link between macroeconomic fundamentals and risk premia documented i.e. by De Grauwe and Ji (2013).

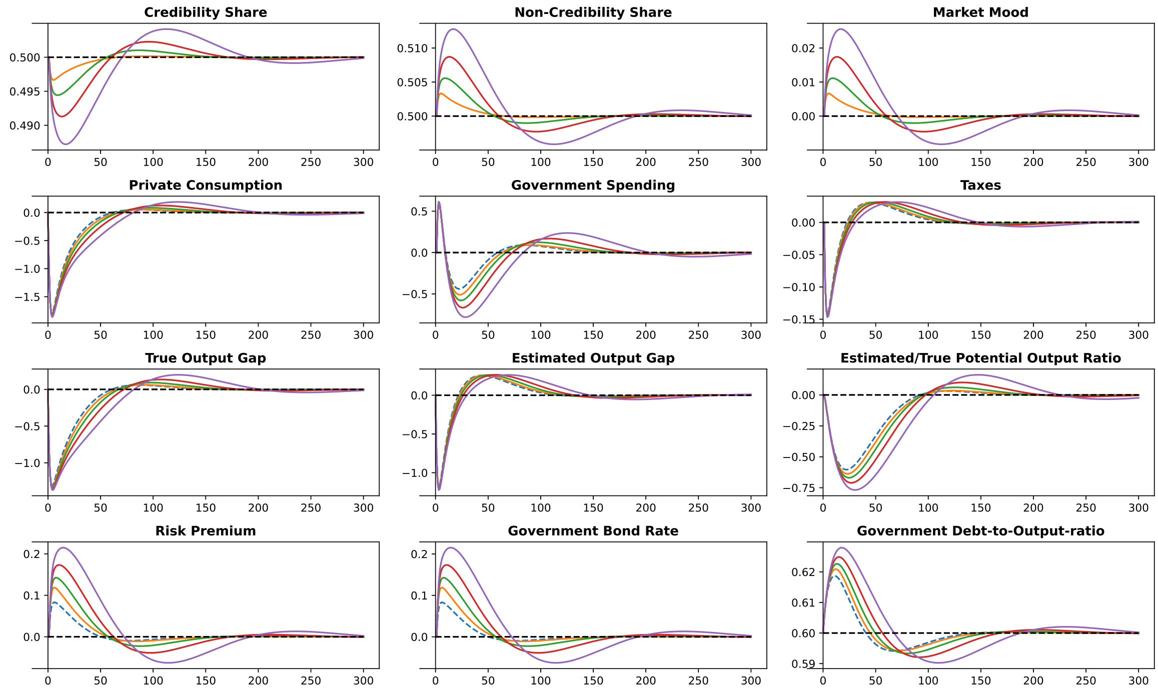


Figure 5: Dynamic adjustment to a one-time negative consumption shock in the baseline (dashed line) and the extended model (with endogenous government credibility, solid line) using the parameter values reported in Table 1 for increasing values of $\mu_b \in [0, 1.2]$.

Figure 5 illustrates how the incorporation of the behavioral endogenous credibility affects the dynamic adjustment of the extended model to a negative private consumption shock relative to the baseline model's reaction (but with $\phi_{gb} = 0.2$ and $\xi_b = 0.00744$ in order to guarantee non-explosive dynamic paths in this and the following simulations). As in the previous case, the negative reaction of private consumption leads to a more pronounced decline in economic activity and, by extension, of the true (but unobservable) potential output and output gap. Noteworthy is also the decrease in the estimated/true potential output ratio that indicates how the adaptive estimated potential output excessively reacts to the decrease in actual output (while the true potential output remains constant by construction). Increasing the "hawkishness" for the given parameter constellation even further than shown above ($\mu_b > 1.2$) would lead to an unstable impulse response. Overall, the expansion of the model thus leads to an additional burden for the stabilization of the model as both private consumption and government spending are inhibited by the poorer financing conditions, with this hurdle growing even further if the “hawkishness” of the bond vigilantes increases.

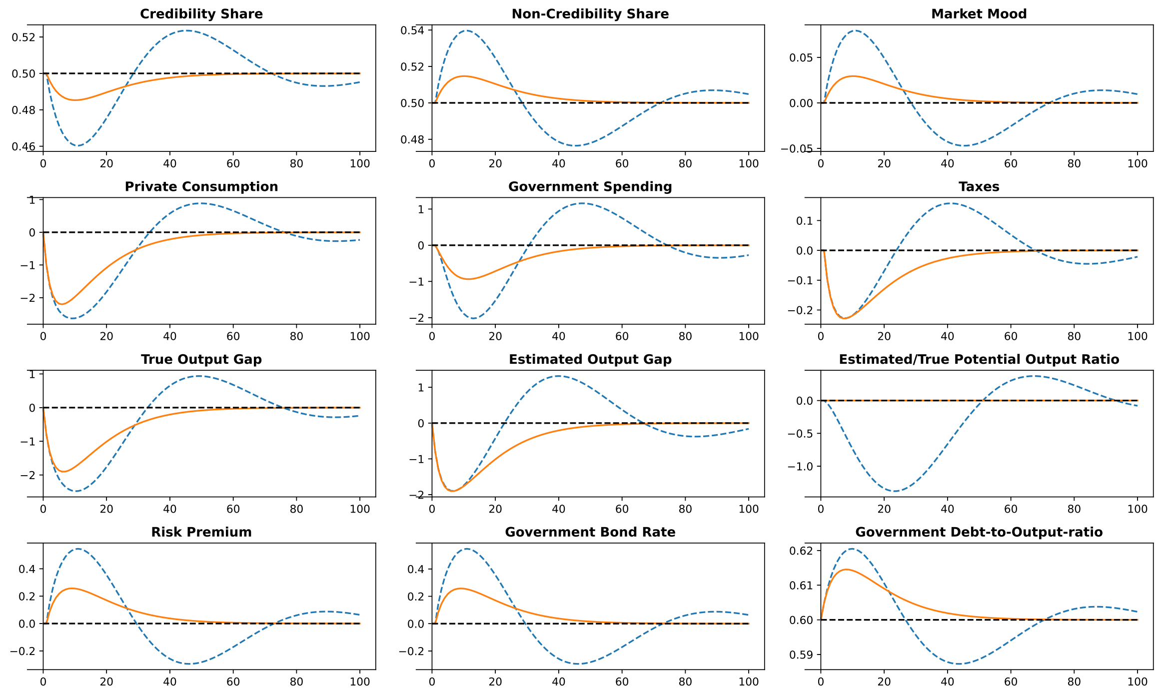


Figure 6: Dynamic adjustment to a one-time negative consumption shock for the extended model with a ”hawkish” bond vigilantes ($\mu_b = 4$) with (dashed line) and without (solid line) OGU for fiscal policy using the parameter values reported in Table 1.

Figure 6 and 7 show the dynamic adjustment of the extended model in presence of a “hawkish” bond vigilantes. This is modeled by setting $\mu_b = 4$, meaning that the government’s credibility among financial markets would remain unchanged if a one-percent increase in the debt-to-GDP ratio is accompanied with a 4-fold increase in the output gap. If the output gap increase is lower or negative, the government’s credibility will decline.[15] In both scenarios either the direct negative consumption shock or the shock to the risk premium (which is then reflected in a higher interest rate) puts pressure on the macroeconomic environment leading to a negative output gap. Due to the tight financial environment this pressure is even reinforced, since this makes it harder for fiscal policy to react to the negative output gap (this holds both for with and without OGU). Altogether considerable volatility is observable, particularly as the more difficult financing conditions not only generate feedback effects on government spending and taxation, but also affect private consumption (see equation (10)). However,

[15]Due to the inclusion of an endogenous government credibility we put an additional burden on the stability on the model. For the simulation of figure 6 and 7 we increased $\phi_{gb} = 1$ in order to get stable model runs.

volatility is particularly high in the presence of OGU, meaning that the destabilizing effects of the bond vigilantes and its strong indicated "hawkishness" lead to a turbulent macroeconomic environment, which is reinforced due to the OGU for fiscal policy with a much longer adjustment period before the shocks have faded out. This suggests that fiscal policy that is constrained by OGU amplifies the negative effects (as displayed by a large marcoecnomic volatility) coming from effects due to the bond vigilantes especially in the case of strong hawkishness.

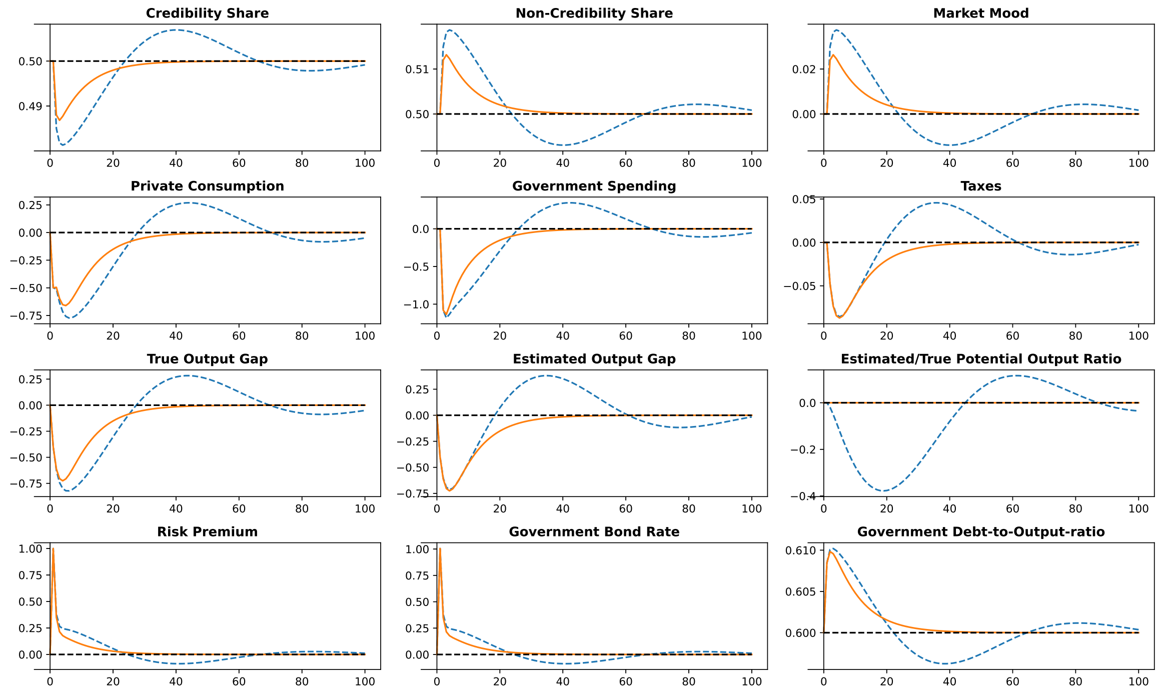


Figure 7: Dynamic adjustment to a one-time positive interest rate shock for the extended model with a "hawkish" bond vigilantes ($\mu_b = 4$) with (dashed line) and without (solid line) OGU for fiscal policy using the parameter values reported in Table 1.

## 6 Introducing Hysteresis in Potential Output

While potential output was assumed so far to be constant for expositional simplicity, we assume now that potential output is affected by past actual output,[16] namely

$$\mathbb{Y}_t \quad = \quad \mathbb{Y}_{t-1} \left( \frac{Y_{t-1}}{\mathbb{Y}_{t-1}} \right)^{\beta_h} . \tag{25}$$

According to equation (25), the past (observable) output $Y_{t-1}$ positively impacts the potential output $\mathbb{Y}_t$, in a similar manner as actual output influences the potential output estimation in standard filtering

[16] We thank one of the referees of this paper for suggesting us to expand our analysis in this direction.

techniques. With this we account for the occurrence of weak hysteresis (Barbosa-Filho, 2022 describes potential output hysteresis with a non-immunity of potential output to demand shocks) and thus provide a rationale for sustained OGU also in longer time horizons. We again evaluate the gap between the estimated potential output $\hat{\mathbb{Y}}_t$ and the true potential output $\mathbb{Y}_t$ by expanding and taking logarithms in equation (2), now using (25):

$$
\begin{aligned}
\ln\left(\hat{\mathbb{Y}}_t \frac{\mathbb{Y}_t}{\mathbb{Y}_t}\right) &= \ln\left(\hat{\mathbb{Y}}_{t-1}\frac{\mathbb{Y}_{t-1}}{\mathbb{Y}_{t-1}}\left(\frac{Y_{t-1}}{\hat{\mathbb{Y}}_{t-1}}\frac{\mathbb{Y}_{t-1}}{\mathbb{Y}_{t-1}}\right)^{\beta_{\hat{y}}}\right) \\
\tilde{\mathrm{y}}_t &= \ln(\mathbb{Y}_{t-1}/\mathbb{Y}_t) + \tilde{\mathrm{y}}_{t-1} + \beta_{\hat{y}}\left(\hat{y}_{t-1}\right) \\
\tilde{\mathrm{y}}_t &= \ln\left(\frac{\mathbb{Y}_{t-1}}{\mathbb{Y}_{t-1}\left(\frac{Y_{t-1}}{\mathbb{Y}_{t-1}}\right)^{\beta_h}}\right) + \tilde{\mathrm{y}}_{t-1} + \beta_{\hat{y}}\left(y_{t-1} - \tilde{\mathrm{y}}_{t-1}\right) \\
\tilde{\mathrm{y}}_t &= -\beta_h y_{t-1} + (1-\beta_{\hat{y}})\tilde{\mathrm{y}}_{t-1} + \beta_{\hat{y}} y_{t-1} \\
\tilde{\mathrm{y}}_t &= (1-\beta_{\hat{y}})\tilde{\mathrm{y}}_{t-1} + (\beta_{\hat{y}} - \beta_h) y_{t-1}, \qquad (26)
\end{aligned}
$$

Comparing equation (26) with equation (3), we can see that due to the introduced hysteresis the gap between the the estimated and the true potential output now additionally depends on the strength of the induced hysteresis $\beta_h$[17]. More specifically, the influence of the actual output gap on the estimation error is now driven by the gap between the adaptiveness parameter $\beta_{\hat{y}}$ and the hysteresis parameter $\beta_h$. Should the strength of the hysteresis parameter exceed the adaptiveness of the potential output estimation ($\beta_{\hat{y}} < \beta_h$), this would result in a negative influence of the output gap on the potential output estimation error. In boom phases ($y_{t-1} > 0$), potential output (which in the case of hysteresis also changes) will be underestimated, while it will be overestimated in recessionary periods. In our simulations however we assume that the adaptiveness effect of the estimation procedure exceeds the hysteresis effect ($\beta_{\hat{y}} > \beta_h$) so that the end-point-bias problem is not affected in its sign, but dampened via the smaller influence of the output gap.[18]

Using the same simulations and settings as in the previous sections, we repeat all simulations now with induced hysteresis. We exemplarily present the dynamics of an one-time positive interest rate shock of the extended model under the presence of hysteresis in Figure 8 below. The results of the remaining simulations can be found in the appendix. Comparing Figure 8 to Figure 7 (the dynamic adjustment with and without hysteresis) we can see that for the baseline scenario (orange line - no OGU) the inclusion of hysteresis creates a more sluggish dynamic adjustment where the (true) output gap oscillates around its long-run steady state value. Comparing the OGU and the non-OGU case

[17] We set $\beta_h = 0.01$ to induce a mild occurrence of weak hysteresis

[18] Note, that $|(\beta_{\hat{y}} - \beta_h)y_{t-1}| < |\beta_{\hat{y}} y_{t-1}|$ and thus $|\tilde{\mathrm{y}}_t| > |\tilde{\mathrm{y}}_t^h|$ where $\tilde{\mathrm{y}}_t^h$ denotes the gap between actual and estimated potential output in the case of hysteresis.

in this setting, a rapprochement of the two scenarios is visible while the dynamic adjustment in the OGU case is still more volatile and long-lasting which supports our results of section 4 and 5.

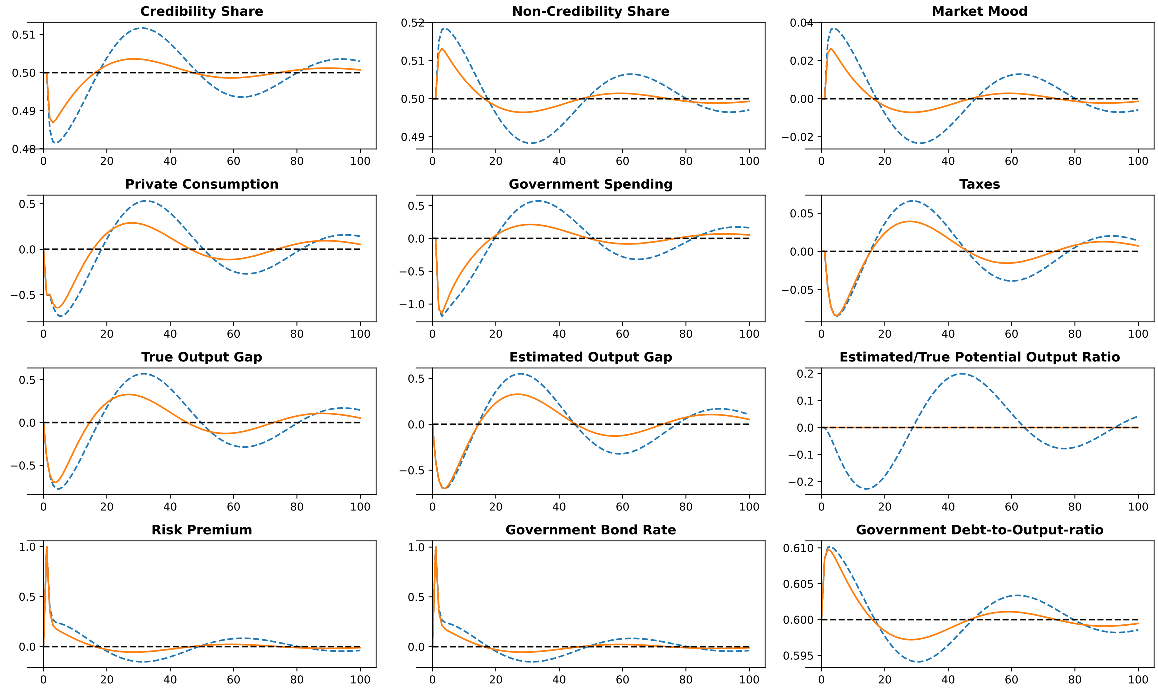


Figure 8: Dynamic adjustment to a one-time positive interest rate shock for the extended model with a "hawkish" bond vigilantes ($\mu_b = 4$) with (dashed line) and without (solid line) OGU for fiscal policy using the parameter values reported in Table 1 with hysteresis.

We thus conclude, that hysteresis (and with this a varying potential output) does not change the essence of our results. While hysteresis changes (depending on its strength) the behavior of the main variables substantially, it also reduces the differences between the OGU and the non-OGU case, while keeping the qualitative results (more volatile and long-lasting adjustments in the OGU case) preserved. The smaller influence of OGU through the incorporation of hysteresis therefore does not invalidate our initial findings but is just a result of the described dynamics of the estimation error being now also dependent on the level of hysteresis. We leave a further investigation of these aspects for future research.

## 7 Concluding Remarks

This paper investigated both analytically and numerically the consequences of uncertainty concerning the economy's true potential output level and the corresponding output gap for the adequateness of fiscal policy. A key focus was also to investigate the interplay of the aforementioned output gap uncertainty with the so-called bond vigilantes which was later updated with a measure of their "hawkishness".

The model was intentionally kept extremely parsimonious to illustrate the mechanisms at work in the most transparent manner. Most notoriously, aggregate investment and thus capital accumulation were abstracted from, so that the true potential output was actually exogenous and constant. As a result, fluctuations in the estimated potential output were solely due to the adaptive adjustment to observable fluctuations in economic activity through processes such as the HP Filter.

The stability analysis of the theoretical model highlighted a key aspect of fiscal policy, namely the interplay between the determination of the risk premium on government debt and the conduct of spending or tax policy. More specifically, the stability analysis showed that *if* the risk premium reacts to the level of government debt, *then* government spending should have a (sufficiently large) debt-stabilizing component. The stabilization of government debt via austerity policies is thus only necessary if markets care about the level of government debt. If they don't, or do so only mildly, the stabilization of debt is not a necessary condition for macroeconomic stability, at least in the short run, as e.g. the Japanese experience over the last two decades has shown. The presence of output gap uncertainty itself was not found to be a key factor for the stability of the model but in the simulation part it was shown that it indeed can play a significant role in explaining higher macroeconomic volatility and thus inefficiencies in fiscal stabilization.

Another decisive result was that the presence of a bond vigilantes that actively evaluate the efficiency of the fiscal policy can itself act as a destabilizing factor. It can therefore led to an unstable system or cause the dynamic adjustments triggered by an exogenous shock to be significantly extended due to the tighter fiscal environment. This destabilization is even reinforced if one includes output gap uncertainty in the model framework. Careful consideration of whether bond markets exhibit such mechanisms should therefore be a key concern for policymakers making decisions regarding the conduct of fiscal policy. While we explicitly abstracted from the analysis of monetary policy in our setting (among other things, because prices are assumed to remain constant), its conduct and interaction with fiscal policy might have a significant impact on the results of our model, and in particular on the effects of the bond vigilantes (we thank one of the referees for raising our attention to this aspect). For instance, a way that would take this into account could be to relate the value of $\mu_b$ with the conduct of monetary policy in the respective country. This would mean that the bond vigilantes would react differently to the fiscal policy depending on the monetary policy stance, which could be either more hawkish (e.g. in the case of a relatively rigorous stability-oriented monetary policy as in the Eurozone) or less hawkish (in the case of a more flexible stance as in Japan). A modeling of the aforementioned scenario could effectively be achieved by assuming that $\mu_b^{EUR} >> \mu_b^{JPY}$. This would open up a new avenue of research that could be explored in future work, namely the fiscal-monetary policy interaction under bounded rationality and endogenous government credibility. The present analysis yields thus the foundation of such a follow-up project.

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# A Appendix - Model with Hysteresis

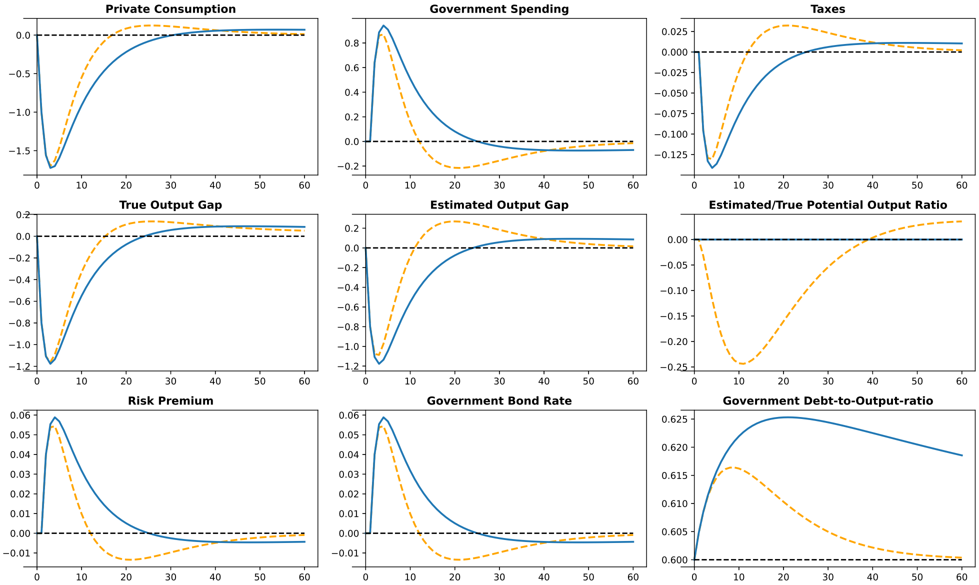


Figure 9: Dynamic adjustments of the simplified model under a known true potential output (continuous line) and an estimated potential output (dashed line) following a negative AR(1) shock to private consumption by one-percent using the parameter values reported in Table 1 with hysteresis.

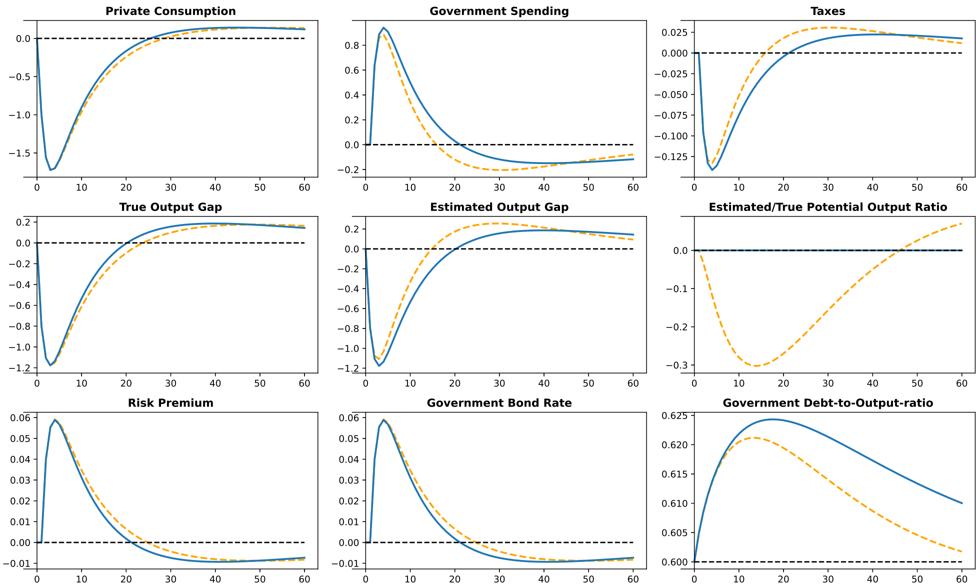


Figure 9 a.): Same simulation as in figure 9 but with consumption and risk premia determination depending on the actual potential output $\mathbb{Y}$ instead of $\hat{\mathbb{Y}}$ (see equations (10) and (12)) with hysteresis.

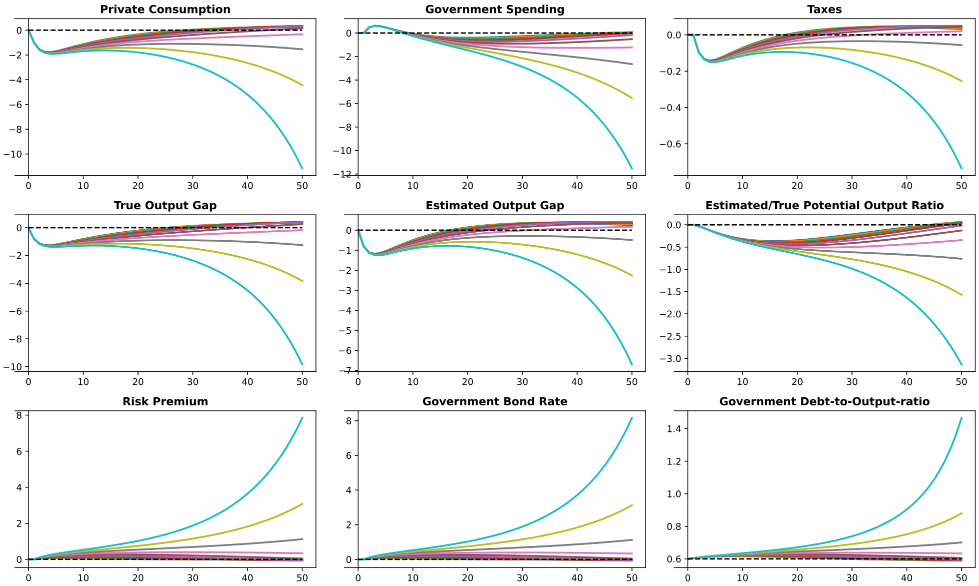


Figure 10: Dynamic adjustments of the baseline model under an estimated potential output following a negative AR(1) shock to private consumption by one-percent using the parameter values reported in Table 1 for increasing values of $\xi_b \in [0, 0.1]$ and $\phi_{gb} = 0.2$ with hysteresis.

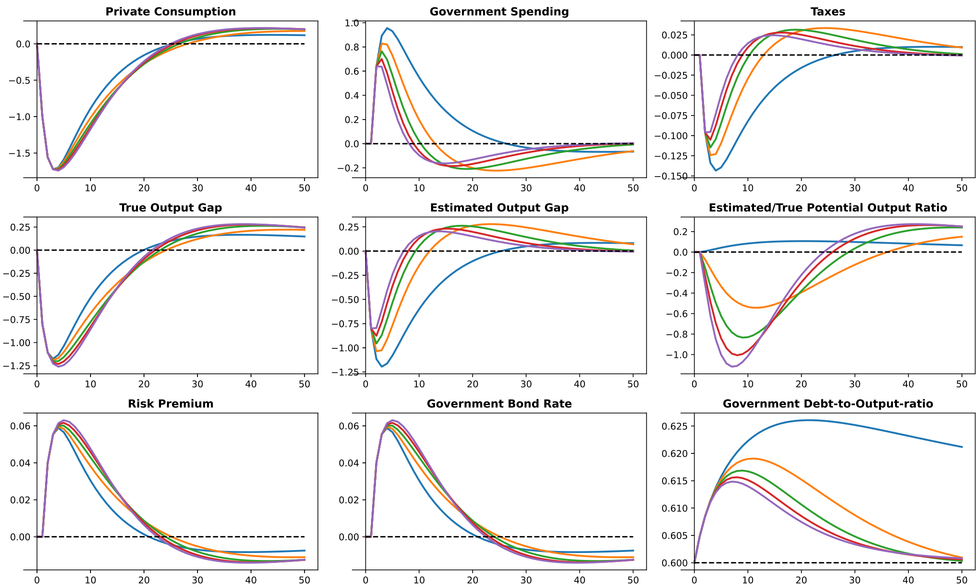


Figure 11: Dynamic adjustments of the baseline model following a negative consumption shock for increasing values of $\beta_{\hat{y}} \in [0, 0.5]$ with hysteresis (remaining values according to Table 1).

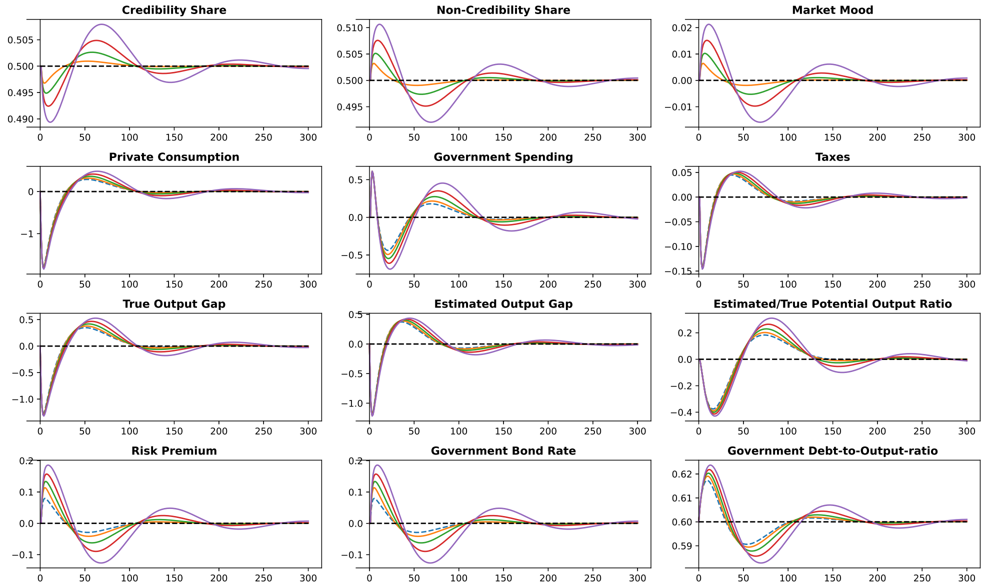


Figure 12: Dynamic adjustment to a one-time negative consumption shock in the baseline (dashed line) and the extended model (with endogenous government credibility, solid line) using the parameter values reported in Table 1 for increasing values of $\mu_b \in [0, 1.2]$ with hysteresis.

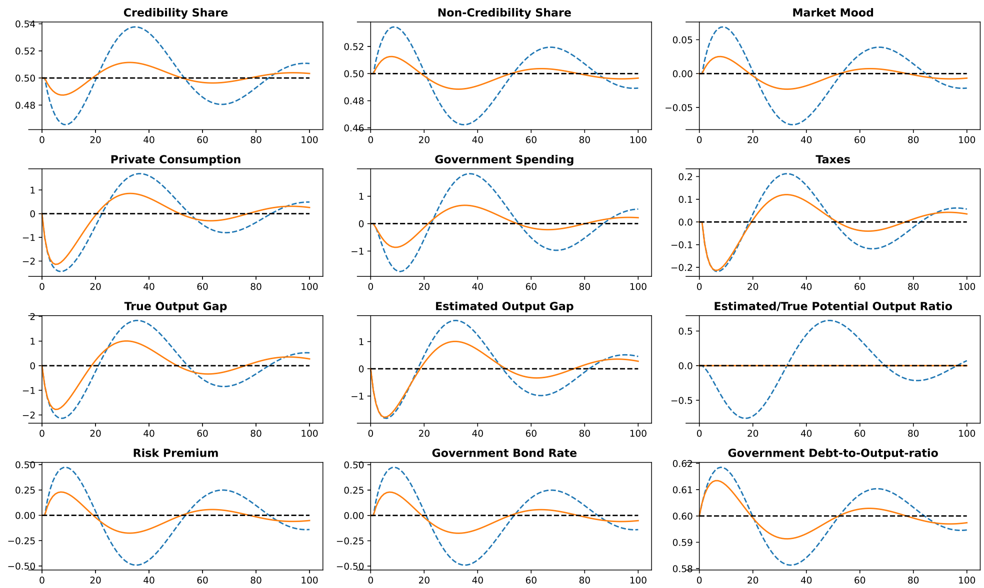


Figure 13: Dynamic adjustment to a one-time negative consumption shock for the extended model with a "hawkish" bond vigilantes ($\mu_b = 4$) with (dashed line) and without (solid line) OGU for fiscal policy using the parameter values reported in Table 1 with hysteresis.