Simple Fiscal Policy Rules: Two Cheers for a Debt Brake!

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(Long) First Draft Version – with mathematical derivations

Abstract

In a New Keynesian DSGE model with non-Ricardian consumers, we show that automatic stabilization according to a counter-cyclical spending rule following the idea of the debt brake results to perform quite well to steer the economy and in terms of welfare. However, it is essential to design the debt brake such that lapses in the spending scheme due to estimation errors in trend output or discretionary fiscal policy actions are booked on an adjustment account and cut future government spending, where discretionary lapses should be corrected faster than lapses due to estimation errors.

Keywords: fiscal policy, debt brake, welfare, dsge.

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1 Introduction

In the political debate, the stabilizing and potentially welfare enhancing effects of counter-cyclical fiscal policy are attracting more and more attention. The International Monetary Fund (IMF) has just recently identified a possible role for such fiscal stimuli in phases of economic downturns. In its *World Economic Outlook*, it is, however, found that the effects of counter-cyclical fiscal policy are complicated and highly dependent on the characteristics of the economy and the fiscal stimulus itself. Special emphasis is laid on the question whether discretionary policy measures should be taken, or whether automatic stabilizers are a better instrument. In a cautious conclusion, the IMF states that automatic stabilizers may be a more adequate instrument to "fine tune" the economy as their responses to cyclical changes of the economy can be expected to be more on time, and the danger of a deficit bias present with discretionary policy is diminished.[1] In case discretionary policy to steer the economy across cyclical fluctuations is not abolished, the IMF suggests a "fiscal watchdog" – charged with identifying changes in the cyclical states of economy, assessing the extent to which fiscal policy is consistent with medium-term objectives, and providing advice on various policy measures – to to bolster the credibility of discretionary policy actions and reduce the deficit bias. It is adumbrated that simple fiscal rules, including sustainable and counter-cyclical elements, may be advantageous instruments (see IMF, 2008; chapter 5). In this paper, we will resume this issue and analyze current proposals in this vein.

The discussion is not as new as it might seem at first sight. Already Allsopp and Vines (2005) and Solow (2005) have noticed that, after quite a time in which the stabilizing role of fiscal policy has been widely neglected because of the basically disappointing experiences in the 1970s, there seems to arise somewhat of a consensus that fiscal policy could, however, be an appropriate instrument to steer the economy. In Europe, a potential role of fiscal stabilization has been more or less seriously discussed since the start of this decade (see e.g. European Commission, 2001). The Stability and Growth Pact of the European Union, adopted in 1997 and amended in 2005, allows member countries for some (sustainable) stabilization by demanding budgets to be 'close to balance or in surplus' without actually calling for corrective means if the corresponding member state does not systematically violate the 3% deficit ceiling.

Since rather recently, a fiscal regime called "debt brake" is being discussed, which is aiming at strengthening the sustainable stabilizing role of fiscal policy. The debt brake is

[1] The deficit bias can be explained by arguments from the political economy as e.g. fiscal illusion of economic subjects (i.e. while citizens fully appreciate the benefits of credit-financed spending and/or tax relief, the same cannot always be said for the associated financing burden), intergenerational income distribution, social polarization (i.e. largely different opinions what governments should spend their money on; see Woo, 2005) or that an incumbent government may also be motivated to raise the debt level so as to restrict the new government's leeway (see Alesina Tabellini, 1990). Those issues are, however, not addressed in more detail within this paper. Nevertheless, Cournède (2007) shows that these mechanisms seem to determine political spending behavior and – allegedly necessary – fiscal consolidation has been delayed exactly because of such reasons.

a proposal to steer fiscal policy according to a simple fiscal rule, i.e., in principle, it follows the quest to find a "Taylor rule" for fiscal policy. The basic idea is that real government expenditures in a certain period, including interest on outstanding debt, should be equal to real trend revenues raised by the government and not fluctuate with cyclical revenue deviations. In principle, this means that in "good times", i.e. in times of output above trend, expenditures should fall short of revenues and, thus, the government should save. In "bad times", i.e. when output is below trend, the government is allowed to deficit-finance some of its expenditures. Actual (discretionary) lapses in this pre-determined spending and potential deficits/surpluses resulting from cyclical revenue fluctuations are memorized on what is called "adjustment account". A positive balance of the adjustment account then forces governments to cut future spending. Hence, this spending rule is supposed to be welfare enhancing due to its counter-cyclical behavior and sustainable as it diminishes the deficit bias and should, for symmetric shocks, have a determined (fixed) level of debt in the long run (see Danninger, 2002; Müller, 2006; German Council of Economic Experts, 2007; Kastrop and Snelting, 2008; and Kremer and Stegarescu, 2008; for a discussion). Rules in this vein have already been implemented in Switzerland in 2001 and it is currently discussed to implement such rules in Germany.

In the present paper, we will analyze the business cycle dynamics and welfare effects of a debt brake and compare them to a balance budget rule and a debt brake augmented by an additional component which move counter-cyclical to GDP (see e.g. Taylor, 2000) – in the following simply referred to as automatic stabilizer – and optimal discretion.[2] We further analyze which are important setscrews of the debt brake and how recent proposals deal with them in the debt brake design. In order to analyze these questions, we construct a conventional DSGE model in the manner of Gali et al. (2007), Leith and Wren-Lewis (2007) and Linnemann and Schabert (2003) with Ricardian and non-Ricardian households, a firm sector with staggered price setting as in Calvo (1983), a monetary authority, for which we assume that it follows a simple Taylor rule, and a fiscal authority that implements a debt brake, automatic stabilizer or a balanced budget rule.

We find that none of the rules currently in the political debate can be considered as the "new Taylor rule" of fiscal policy. All rules reviewed perform significantly worse than optimal discretion. Fundamentally, the Taylor rule is advisable because the "Taylor principle" fits to all shocks. Unfortunately, none of the proposed policy rules embeds such a principle which fits to all shocks. Therefore, our general finding is that a rule which steers fiscal expenditures along the trend path and abstains from activism is preferable. We find that the balance

[2]Note that, in the public discussion, an automatic stabilizer is usually defined to have a constant government spending path tied to the evolution of trend revenues like the debt brake. In the economic literature, reactions of government spending are often modelled to (additionally) depend negatively on deviations of output from trend, which gives government spending a more active role. In this paper, we term the latter "automatic stabilizer" referring to the literature (basically starting with e.g. Taylor, 2000), while this obviously does not fully correspond to the term used politically. The difference will become clearer when setting up the model. However, the reader is urged to keep this difference in mind.

budget rule potentially destabilizes the economy and gives rise to sunspot equilibria. Due to erratic spending schemes, the balanced budget regime destabilizes the economy as it triggers boom-bust cycles in consumption among non-Ricardian households. As monetary authorities do not have a leverage on these hand-to-mouth consumers, such a fiscal policy stance may give rise to sunspot equilibria, even if the central bank adopts the Taylor principle (see also Gali, 2004). Accordingly, the overall welfare loss would increase by 11% if fiscal authorities would switch from a debt brake to a balanced budget regime. The debt brake, in principle, ties real government spending to real government trend revenue. However, it also acts mildly pro-cyclical, which can be attributed to the interest payments on outstanding debt and to the commitment to keep overall debt constant over time. For a shock positively influencing actual real government revenue, this implies that these additional funds are gradually spend over time. The conventional automatic stabilizer basically augments the debt brake by explicitly necessitating stabilization in output. This, indeed, generates, in principle, a counter-cyclical response to any economic shock. Note, however, as the government equally has to redeem interest on debt and is committed towards a constant level of real debt in the long run, the overall fiscal stance does not necessarily move counter-cyclical to GDP, but depends on the size of the different effects. A distinct difference to the two previous rules stems from the need to design a feedback from tax rates to changes in government debt in order to attain a stable equilibrium. Without this feedback, the adaption of government spending due to the adjustment account to real government expenditures would not suffice to stabilize debt. In terms of welfare, calculated as an average consumer loss function, a conventional debt brake and a debt brake augmented by an automatic stabilizer are very comparable as the welfare difference is 4%. Fundamentally, the automatic stabilizer wins the DSGE horse race because it keeps expenditures itself closer to real trend than the debt brake itself. Therefore it attenuates the adverse effects of government spending on wages, in particular, in the case of cost-push shock, as it does not crowd in private consumption as much as the debt brake does.

Regarding the design of a debt brake, we find that the feedback of the adjustment account to real government spending should ideally differ with the shock. Discretionary government spending shocks should be corrected as soon as possible and, thus, have a higher feedback, while all the other shocks (generating expectation errors) should fade out slowly over time in order to keep fluctuations actively introduced into the system low (see also Kremer and Stegarescu, 2008; who find the same result in an empirical analysis using German data). Debt brakes already in action or proposed have the problem that trend estimation is a difficult task. Therefore, we analyze the effects if fiscal authorities persistently over- or underestimate the growth trend. We find that our preferred design of a debt brake is well suited to scope with this problem. In detail, we show that, if trend is over- (under)-estimated, government spending tends to be too high (low). Whenever the feedback from the adjustment account is set equal to the values proposed, it is well suited to prevent debt from dramatically increasing, while equally stabilizing inflation and output. If the feedback of the adjustment account is too low, debt dramatically increases nd the economy is subject to more pronounced cycles in GDP and inflation. Thus, we conclude that the problem of trend mis-estimation gives a strong motive for the installation of an adjustment account.

Debt brakes in place tie government spending to projected revenues and correct this by a counter-cyclical component to reduce (augment) spending in "good" ("bad") times. Constructing the debt brake like this, one has to be very careful to adapt the reaction of government spending to the elasticities of revenues and output correctly, as the latter tends to be lower than the first, differing in shocks, however). If this adaption is not done correctly, one easily generates a strong pro-cyclical feedback of the debt brake, which is, in terms of welfare, not quite as bad as the balanced budget rule, but far from the performance of the basic idea of a debt brake.

Related literature: As already mentioned earlier, the focus of economic stabilization has, for quite a while, been devoted to monetary policy alone (see e.g. Clarida et al., 1999; and Woodford, 2003; for an overview). One reason may have been that, in the classical theory, Ricardian equivalence dominated the scientific arena. Ricardian equivalence means that, as households know that higher (potentially deficit-financed) government spending today means higher taxes tomorrow, the fiscal multiplier is zero (under the assumption of distortionary taxation, it may even become negative, see Sutherland, 1997; and Hemming et al., 2002). However, challenging the assumption of full Ricardian equivalence, already Auerbach and Kotlikoff (1987) pointed out that, if the crowding-out effects resulting from a fiscal stimulus need more time to die out than the impulse to affect economic behavior, positive multipliers can be expected in the short or middle run. The extension of conventional models by shorter time horizons and non- (or only partly) altruistic behavior of economic subjects in e.g. overlapping generation models further pointed in the direction that fiscal policy was, most likely, influential (see e.g. Blanchard, 1985; and Mankiw, 2000). The fact that, empirically, there was and is large evidence suggesting that, indeed, fiscal multipliers with respect to GDP are significantly different from zero (see e.g. Baxter and King, 1993; Fatas and Mihov, 2001; Blanchard and Perotti, 2002; Perotti, 2005; Heppke-Falk et al., 2006), has led to the development of models incorporating such features. The first wave of DSGE-papers studied fiscal policy alongside monetary policy and focussed on how the stability properties of monetary policy rules are influenced by fiscal policy, basically building on Leeper's (1991) active and passive monetary policy (see e.g. Lubik, 2003; Kremer, 2004; Railavo, 2004; Schmitt-Grohé and Uribe, 2007; Leith and von Thadden, 2008; and Stehn and Vines, 2008). Only a little later, Gali et al. (2007) showed that the reactions of macroeconomic variables to a fiscal policy shock found empirically can (only) be reconciled in DSGE models with rule-of-thumb consumers as well as sticky prices and deficit financing. Going a step further, Straub and Tchakarov (2007), Leith and Wren-Lewis (2007) and Gali and Monacelli (2008) show that, indeed, counter-cyclical fiscal policy may be welfare enhancing in such setups. The main reason – in short – is that such fiscal actions help to at least partly internalize the externalities caused by the implemented rigidities and market imperfection and keep fluctuations in inflation and disutility of labor smaller than without stabilization. Mayer and

Grimm (2008) approve that counter-cyclical tax rules can also improve welfare for supply-side shocks. They show that this even holds for balanced budget rules if the tax rule is contingent on the observed welfare gap or on the shock. The latest public discussion is focussing on which fiscal rule should be followed. In this paper, we will contribute to the discussion by comparing the debt brake, an automatic stabilizer and a balanced budget rule both in terms of their effect on macroeconomic variables and in terms of welfare and point out which are important setscrews to be taken into account.

We will proceed as follows. Section 2 introduces the model used and derives the log-linearized version. In section 3, we analyze the impulse responses of our model, while section 4 contains some welfare considerations. In section 5, we have a look at what are important issues to deal with when constructing a debt brake in reality. Section 6 concludes. A detailed mathematical appendix is added.

2 The model

In this section, we present a New Keynesian DSGE model with firms, households as well as monetary and fiscal authorities. As standard, firms are categorized into the final good sector and a continuum of intermediate good producers. Intermediate good producers have some monopoly power over prices that are set in a staggered way following Calvo (1983). Households obtain utility from consumption, public goods and leisure, and further invest in state contingent securities. The household sector is partitioned into so called Ricardian and Non-Ricardian Households. The Ricardian households, with share $(1-\lambda)$, own the firms and are able to save, i.e. invest in bonds and state contingent securities, whereas Non-Ricardian households, with share λ, are hand to mouth consumers in the sense that they spend each period their total labor income. Monetary policy is assumed to be given by a standard Taylor rule. Government expenditures are financed by distortionary taxes levied on wages and consumption. Fiscal policy is implemented by a spending rule incorporating the debt brake or the balance budget rule. The model is built on the framework of Gali, Lopez-Salido and Valles (2007), Leith and Wren-Lewis (2007), and Mayer and Grimm (2008).

In what follows, any aggregated variable X_t is defined by a weighted average of the corresponding variables for each consumer type, i.e.

$$X_t = \lambda X_t^r + (1-\lambda)X_t^o, \tag{1}$$

where the superscripts o and r stand for optimizing Ricardian consumers and rule-of-thumb consumers, respectively. Further, variables with a "bar" (as in $\bar{X}$) indicate the deterministic steady-state value of the variable X, while variables with a "hat" (as in $\hat{X}$) denote percentage deviations from the steady-state value of this variable X as given by

$$\hat{X}_t = log\left(\frac{X_t}{\bar{X}}\right) \approx \frac{(X_t - \bar{X})}{\bar{X}}. \tag{2}$$

2.1 Firms and Price Setting

2.1.1 Final good producers

The final good is bundled by a representative firm which operates under perfect competition. The technology available to the firm is

$$Y_t = \left[\int_0^1 Q_t(j)^{\frac{\epsilon_t - 1}{\epsilon_t}} dj \right]^{\frac{\epsilon_t}{\epsilon_t - 1}}, \tag{3}$$

where Y_t is the final good, $Q_t(j)$ are the quantities of intermediate goods, indexed by $j \in (0,1)$, and $\epsilon_t > 1$ is the time-varying elasticity of substitution in period t. Profit maximization implies the following demand schedule for all $j \in (0,1)$

$$Q_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\epsilon_t} Y_t. \tag{4}$$

The zero-profit theorem implies $P_t = \left[\int_0^1 P_t(j)^{(1-\epsilon_t)} dj \right]^{\frac{1}{(1-\epsilon_t)}}$, where $P_t(j)$ is the price of the intermediate good $j \in (0,1)$. In a similar way to Smets and Wouters (2003), we assume that ϵ_t is a stochastic parameter. This implies that $\Phi_t = \frac{\epsilon_t}{(1-\epsilon_t)}$ reflects the time-varying markup in the goods market. We get $\Phi_t = \Phi + \hat{\Phi}_t$, where we assume that $\hat{\Phi}_t$ is i.i.d. normal distributed. Then, $\Phi = \frac{\epsilon}{(1-\epsilon)}$ is the deterministic markup which holds in the long-run flexible price steady state.

2.1.2 Intermediate good producers and prices

The intermediate good sector behaves in the usual manner. Profit by firm j at time t is given by

$$\Pi_t(j) = P_t(j) Q_t(j) - W_t(1 + \tau_t^w) N_t(j), \tag{5}$$

where W_t denotes the nominal wage rate, N_t are labor services rented and τ_t^w are social security contributions of firms. The production technology available to firms is given by

$$Q_t(j) = A_t \cdot N_t(j), \tag{6}$$

in which labor is the sole input. For analytical simplicity, it is linear in the shock, where $E_t\{A_t\} = 1$. Real marginal costs per firm can, thus, be represented by

$$mc_t(i) = \frac{W_t(1 + \tau_t^w) N_t(j)}{P_t Q_t(j)} = \underbrace{A_t^{-1}}_{= N_t / Q_t} [(1 + \tau^w) w_t]. \tag{7}$$

Using equation (5), we can state real profits to be

$$\frac{\Pi_t(j)}{P_t} = \left[\frac{P_t(j)}{P_t} - mc_t(j) \right] Y_t(j). \tag{8}$$

Hence, a firm resetting its price in period t will seek to maximize

$$E_t \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} \left[\frac{P_t(j)}{P_{t+k}} - mc_{t+k}(j) \right] Q_{t+k}(j), \tag{9}$$

with respect to $P_t(j)$ and $Q_{t+k}(j)$, where θ_p is the exogenous Calvo probability that prices remain unchanged (see Calvo, 1983). The product demand constraint $Q_{t+k}(j)$ is given by equation (4), which is the isoelastic demand function. $\Lambda_{t,t+k}$ denotes the stochastic discount factor of shareholders, to whom profits are redeemed. It is defined as $\Lambda_{t,t+k} = (U_C(C_{t+k})/U_C(C_t))$. β denotes a discount factor with $\beta \in (0, 1)$. The corresponding Lagrangian is thus given by

$$E_t \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} \left\{ \left[\frac{\tilde{P}_t(j)}{P_{t+k}} - mc_{t+k}(j) \right] Q_{t+k}(j) - \vartheta^j_{t+k} \left[Q_{t+k}(j) - \left(\frac{\tilde{P}_t(i)}{P_t} \right)^{-\epsilon} Y_{t+k} \right] \right\},$$

where $\tilde{P}_t(i)$ is the optimal reset price and ϑ^j_t denotes the Lagrangian multiplier. The combination of the resulting first-order conditions yields (see Appendix B)

$$E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} \left(\frac{\tilde{P}_t(i)}{P_{t+k}} \right)^{-\epsilon} Y_{t+k} \left[\frac{1}{P_{t+k}} - \epsilon \left(\frac{1}{P_{t+k}} - \frac{mc_{t+k}(j)}{\tilde{P}_{t+k}(j)} \right) \right] \right\} = 0. \tag{10}$$

2.2 The Household Sector

We assume a continuum of households indexed by $j \in (0, 1)$ of which $(1 - \lambda)$ households are assumed to own the assets such as contingent claims, i.e. they are Ricardian consumers, whereas the rest λ has a consumption ratio of one, i.e. they are Non-Ricardian consumers, rule-of-thumb consumers or liquidity-constraint consumers. Let us assume that any household j is characterized by the following lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t U^i_t \left(C^i_t(j), L^i_t(j) \right), \tag{11}$$

where $i = o, r$ indicates optimizing and rule-of-thumb households, respectively.

In what follows, we will first describe the optimizing households' behavior and, then, turn to the rule-of-thumb consumers.

2.2.1 Optimizing Households

The per-period utility function for optimizing households is given by

$$U^o_t(j) = \zeta_t \left[(1 - \chi) log \left(C^o_t(j) \right) + \chi log \left(G_t \right) + \upsilon_t log \left(L^o_t(j) \right) \right], \tag{12}$$

where ζ_t is a common preference shock to all optimizing households, with $E\{\zeta_t\} = \bar{\zeta} = 1$. $L^o_t(j)$ is household j's leisure, where $N^o_t(j) = 1 - L^o_t(j)$ gives the corresponding labor supply of household j. $\upsilon_t > 0$, with $E_t\{\upsilon_t\} = \upsilon$, measures how leisure is valued compared to consumption $C_j^o(j)$. $\chi \in (0,1)$ measures the relative weight of public goods consumption G_t. The flow budget constraint of optimizing households in real terms is given by

$$(1+\tau_t^C)C_t^o(j) + \frac{B_{t+1}^o(j)}{P_t R_t} \leq (1-\tau_t^d)\frac{W_t}{P_t}N_t^o(j) + \frac{\Pi_t^o(j)}{P_t} + \frac{B_t^o(j)}{P_t}, \tag{13}$$

where B_t is a bond issued by the government. The bond pays a gross interest equal to the risk free nominal rate R_t, which is assumed to be the monetary authority's policy instrument. W_t is the nominal wage rate. As we assume that the productivity of Ricardian and Non-Ricardian consumers is identical and that their labor services offered to firms are perfect substitutes we can drop the superscript o and r in the following regarding wages. $\Pi_t^o(j)$ are nominal profits from the intermediate good sector, which implies that we assume that those firms are owned by the optimizing households. τ_t^d is a distortionary tax rate levied on nominal labor income, while τ_t^C is a consumption (quasi value added) tax.

Each optimizing household now maximizes his utility, equation (11) – given equation (12) – with respect to consumption, leisure and bond holdings subject to the intertemporal version of the budget constraint, equation (13). We find that (see Appendix C)

$$\frac{\zeta_t}{C_t^o(j)} = \beta R_t E_t \left\{ \frac{1+\tau_t^C}{1+\tau_{t+1}^C} \cdot \frac{\zeta_{t+1}}{C_{t+1}^o(j)} \cdot \frac{P_t}{P_{t+1}} \right\} \tag{14}$$

is the consumption Euler equation for optimizing households and derive

$$\frac{L_t^o(j)}{C_t^o(j)} = \frac{\upsilon_t}{(1-\chi)} \cdot \frac{(1+\tau_t^C)}{(1-\tau_t^d)} \cdot w_t \tag{15}$$

as the labor supply schedule of optimizing households expressed in terms of leisure, where $w_t = \frac{W_t}{P_t}$ and $L_t^o(j) = [1 - N_t^o(j)]$.

2.2.2 Rule-of-Thumb Consumers

Turning to the non-optimizing, i.e. the rule-of-thumb households, who do not have access to capital markets, we assume that their per-period utility function is also given by an equation analogue to equation (12), i.e.

$$U_t^r(j) = \zeta_t \left[(1-\chi)log\left(C_t^r(j)\right) + \chi log\left(G_t\right) + \upsilon_t log\left(L_t^r(j)\right)\right], \tag{16}$$

where only the superscript o has to be substituted by r. Their lifetime utility is given by equation (11). However, as they do not have access to the capital market, their budget constraint becomes static and is given by

$$(1+\tau_t^C)C_t^r(j) = (1-\tau_t^d)\frac{W_t}{P_t}N_t^r(j), \tag{17}$$

which implies that they spend all their per-period income. Note further, that $N_t^r = 1 - L_t^r$ also applies. Hence, rule-of-thumb consumers maximize equation (11) – given equation (16) – with respect to $C_t^r(j)$ and $L_t^r(j)$ subject to the intertemporal version of the static budget constraint, equation (17). We get (see Appendix C)

$$\frac{C_t^r(j)}{L_t^r(j)} = \frac{(1-\tau_t^d)}{(1+\tau_t^C)} \frac{(1-\chi)}{\upsilon_t} w_t, \tag{18}$$

which, substituted in equation (17) and remembering that $N_t^r = 1 - L_t^r$ yields

$$N_t^r(j) = \frac{(1-\chi)}{(1-\chi)+\upsilon_t} \;\Leftrightarrow\; L_t^r(j) = \frac{\upsilon_t}{(1-\chi)+\upsilon_t}. \tag{19}$$

Hence, labor supply by rule-of-thumb consumers is exogenously fixed by the shock parameter υ_t, which values leisure compared to consumption, where $E_t\{\upsilon_t\} = \upsilon$. Further, it is determined by $(1-\chi)$, which gives the relative weight of private consumption. Using equation (19) and equation (18), we find that

$$C_t^r(j) = \frac{(1-\chi)}{(1-\chi)+\upsilon_t} \cdot w_t \cdot \frac{(1-\tau_t^d)}{(1+\tau_t^C)}. \tag{20}$$

2.3 Fiscal Authorities

The government issues bonds B_{t+1} each period (which have to be repaid with interest in the following period), and collects consumption taxes $\tau_t^C P_t C_t$ and labor income taxes $\tau_t^L W_t N_t$, where $\tau_t^L = \tau_t^w + \tau_t^d$. The receipts are used to finance government expenditure $P_t G_t$ and interest on outstanding debt $R_{t-1} B_t$ of the previous period (where in R_{t-1}, the re-payment is included). Hence, the government's flow budget constraint reads

$$B_{t+1} + \tau_t^L W_t N_t + \tau_t^C P_t C_t = R_{t-1} B_t + P_t G_t. \tag{21}$$

Expressing equation (21) in real terms implies dividing it by P_t. Further, we normalize equation (21) by dividing it by $\bar{Y}$, where $\bar{Y}$ is the steady-state output of the economy, i.e. the trend-output within our model. This yields

$$\frac{B_{t+1}}{P_t \bar{Y}} + \frac{\tau_t^L w_t N_t}{\bar{Y}} + \frac{\tau_t^C C_t}{\bar{Y}} = \frac{R_{t-1} B_t}{P_{t-1} \bar{Y}} \frac{P_{t-1}}{P_t} + \frac{G_t}{\bar{Y}}. \tag{22}$$

Defining $\tilde{b}_t = \frac{B_t}{P_{t-1}\bar{Y}}$ as the cyclically adjusted debt, and government tax revenues as $\Psi_t = \tau_t^L W_t N_t + \tau_t^C P_t C_t$, where

$$\frac{\Psi_t}{P_t \bar{Y}} = \frac{\tau_t^L w_t N_t}{\bar{Y}} + \frac{\tau_t^C C_t}{\bar{Y}}, \tag{23}$$

equation (22) rewrites to

$$\tilde{b}_{t+1} + \frac{\Psi_t}{P_t \bar{Y}} = R_{t-1} \tilde{b}_t \frac{P_{t-1}}{P_t} + \frac{G_t}{\bar{Y}}. \tag{24}$$

For later use, we will further define

$$b_t = \tilde{b}_t - \bar{b} = \frac{B_t}{P_{t-1}\bar{Y}} - \frac{\bar{B}}{\bar{P}\bar{Y}} \tag{25}$$

as the deviation of the percentage of the cyclically adjusted debt from its steady-state ratio. In what follows, we will describe the different fiscal spending rules in more detail.

2.3.1 Balanced Budget Rule

As a benchmark for a sustainable spending rule, we introduce a balanced budget rule, which implies that – as government spending is usually planned at least one period in advance – the government is not allowed to spend more than the projected funds raised by the government. Any expectation errors, i.e. differences between projected and actual funds raised by the government, and (active) discretionary spending shocks ν_t are booked on an adjustment account AC_t to memorize lapses in the spending behavior. Thus, (ex-ante) spending according to the balance budget rule is determined by projected revenues minus previous balances booked on the adjustment account, i.e. $E_{t-1}\{\Psi_t\} - \rho \cdot AC_{t-1}$, where ρ is a parameter indicating how much effect earlier lapses in the spending behavior have on current spending. It can be interpreted as the speed of adjustment. This implies, actual (ex-post) spending is given by

$$(R_{t-1} - 1)B_t + P_t G_t = \underbrace{E_{t-1}\{\Psi_t\} - \rho AC_{t-1}}_{=\textit{Rule based spending}} + \nu_t. \tag{26}$$

The adjustment account for the balanced budget rule reads

$$AC_t = (1-\rho)AC_{t-1} + \nu_t + \underbrace{E_{t-1}\{\Psi_t\} - \Psi_t}_{\textit{Expectation error}}. \tag{27}$$

In normalized real terms, this reads

$$(R_{t-1} - 1)\tilde{b}_t + \frac{G_t}{\bar{Y}} = E_{t-1}\left\{\frac{\Psi_t}{P_t\bar{Y}}\right\} - \rho \cdot \frac{P_{t-1}}{P_t} \cdot ac_{t-1} + \frac{\nu_t}{P_t\bar{Y}} \tag{28}$$

and

$$ac_t = (1-\rho)\frac{P_{t-1}}{P_t} \cdot ac_{t-1} + \frac{\nu_t}{P_t\bar{Y}} + E_{t-1}\left\{\frac{\Psi_t}{P_t\bar{Y}}\right\} - \frac{\Psi_t}{P_t\bar{Y}}, \tag{29}$$

where $ac_t = \frac{AC_t}{P_t\bar{Y}}$.

2.3.2 Debt Brake and Automatic Stabilizer

In the political debate – summarized under the heading "debt brake" –, there is quite a discussion to implement simple spending rules that give counter-cyclical impulses to the economy as pointed out in the introduction. The main idea is that real spending, including interest on outstanding real debt, should be equal to real trend revenues, i.e. $\frac{\bar{\Psi}}{\bar{P}}$ in our model (see Danninger, 2002; German Council of Economic Experts, 2007; Kastrop and Snelting, 2008; and Kremer and Stegarescu, 2008 for a discussion). It is counter-cyclical because, whenever output/revenue is above trend, the government saves, while in times of output/revenue above trend, the government deficit-finances part of its expenditures.

An automatic stabilizer as it is usually modelled is a public revenue and spending mechanism that automatically and more actively than the debt brake just described gives a counter-cyclical fiscal impulse to the economy on the demand side (see Taylor, 2000; Artis and Buti, 2000; or Buti et al., 2001). Classical examples for such automatic stabilizers are income taxation (on the revenue side) and unemployment insurance (on the expenditure side). In principle, the debt brake and the automatic stabilizer are rather similar. However, for a conventional automatic stabilizer, real government expenditures, which are still basically restricted by the revenue side, have to be augmented by a more active counter-cyclical component compared to the debt brake. The counter-cyclical component is given by $\left(\bar{Y}/Y_t\right)^{\alpha}$, which actively diminishes spending for $\bar{Y} < Y_t$ and vice versa, where $\alpha > 0$ captures the magnitude of the automatic reaction of government spending to output deviations from trend.

Regarding the adjustment account, we have to differentiate between the two rules. For both rules, we know that we have to book (active) discretionary spending shocks ν_t as they are never part of the spending rule and, hence, have to be corrected in future periods. However, the rule-based spending differs in both cases and, hence, what has to be booked on the account differs. First, for the debt brake, i.e. $\alpha = 0$, we only have to book the difference between real normalized trend revenue and real normalized true revenue, i.e. $\frac{\bar{\Psi}}{\bar{P}\bar{Y}} - \frac{\Psi_t}{P_t Y_t}$ as debt accumulates whenever trend exceeds true revenue. Second, for the convectional automatic stabilizer, i.e. $\alpha > 0$, we only have to book expectation errors regarding the cyclical situation of the economy, i.e. $E_{t-1}\left\{\left(\bar{Y}/Y_t\right)^{\alpha}\right\} - \left(\bar{Y}/Y_t\right)^{\alpha}$ as such errors generate spending that does not conform with the rule.

This discussion can be summarized formally (in normalized terms, i.e. divided by $\bar{Y}$) by

$$(R_{t-1} - 1)\tilde{b}_t + \frac{G_t}{\bar{Y}} = \underbrace{\frac{\bar{\Psi}}{\bar{P}\bar{Y}} \cdot E_{t-1}\left\{\left(\frac{\bar{Y}}{Y_t}\right)^{\alpha}\right\} - \rho \cdot \frac{P_{t-1}}{P_t} ac_{t-1}}_{=\text{Rule based spending}} + \frac{\nu_t}{P_t \bar{Y}}, \tag{30}$$

where ν_t is a (discretionary) government spending shock and $ac_t = \frac{AC_t}{P_t \bar{Y}}$. Because the budget plans are usually made at least one period ahead, in the case of the automatic stabilizer, the government sets spending in t according to the projected cyclical situation in t at time $(t-1)$. Note further that, for $\alpha = 0$, we have the spending rule according to the debt brake, while for $\alpha > 0$, the conventional automatic stabilizer applies. For the adjustment account, it holds that

$$ac_t = (1-\rho)\cdot\frac{P_{t-1}}{P_t}\cdot ac_{t-1}+\frac{\nu_t}{P_t\bar{Y}}+\frac{\bar{\Psi}}{\bar{P}\bar{Y}}\cdot\underbrace{\left[E_{t-1}\left\{\left(\frac{\bar{Y}}{Y_t}\right)^{\alpha}\right\}-\left(\frac{\bar{Y}}{Y_t}\right)^{\alpha}\right]}_{=\textit{Automatic Stabilizer};\ \alpha>0,\ \varrho=0}$$
$$+\underbrace{\varrho\left[\frac{\bar{\Psi}}{\bar{P}\bar{Y}}-\frac{\Psi_t}{P_t\bar{Y}}\right]}_{\textit{Debt Brake};\ \alpha=0,\ \varrho=1}, \tag{31}$$

where $\alpha = 0$ and $\varrho = 1$ for the debt brake, and $\alpha > 0$ and $\varrho = 0$ for the automatic stabilizer. Note that, as the government is committed towards keeping real debt constant in the long run, debt services and the adjustment account can almost chancel out the automatic stabilizer component such that the fiscal stance might only move mildly counter-cyclical to GDP.

2.4 Market Clearance

In clearing of factor and goods markets, the following conditions are satisfied

$$Y_t = C_t + G_t, \tag{32}$$

where $C_t = \lambda C_t^r + (1-\lambda)C_t^o$ is aggregated consumption.[3] Further,

$$Y_t(j) = Q_t(j) \tag{33}$$

and

$$N_t = \int_0^{\lambda} N_t^r(j)dj + \int_{\lambda}^{1} N_t^o(j)dj. \tag{34}$$

2.5 Linearized Equilibrium Conditions

In this section, we summarize the model by taking a log-linear approximation of the key equations around a symmetric equilibrium steady state.

Firms: Log-linearizing the marginal cost function, equation (7), yields

$$\hat{mc}_t(i) = -\hat{A}_t + \hat{w}_t + \iota^w\hat{\tau}_t^w, \tag{35}$$

where $\iota^w = \frac{\bar{\tau}^w}{(1+\bar{\tau}^w)}$. From the production technology, equation (6), we know that

$$\hat{N}_t = \hat{Y}_t - \hat{A}_t. \tag{36}$$

[3]Note that, within each group $i = o, r$ each household consumes the same due to constant labor supply for rule-of-thumb consumers and state-contingent claims for optimizing consumers (see also Woodford, 2003; and Appendix C for details).

Solving the firm's optimality condition for the optimal reset price $\tilde{P}_t(j)$ and following Gali et al. (2001), we can derive the Phillips curve (see Appendix B)

$$\hat{\pi}_t = \beta \cdot E_t\{\hat{\pi}_{t+1}\} + \kappa \cdot \hat{mc}_t + \hat{\epsilon}_t, \tag{37}$$

where

$$\kappa = \frac{(1-\theta_p)(1-\beta\theta_p)}{\theta_p}.$$

Note that we defined $\hat{\pi}_t = \hat{P}_t - \hat{P}_{t-1}$.

Households: The consumption Euler equation expressed in aggregated variables and deep parameters reads (see Appendix C)

$$\hat{C}_t = E_t\hat{C}_{t+1} - \Theta_n E_t\Delta\hat{N}_{t+1} + \iota^C E_t\Delta\hat{\tau}^C_{t+1} - E_t[\hat{R}_t - \hat{\pi}_{t+1}] + \Theta_\upsilon E_t[\hat{\upsilon}_t - \hat{\upsilon}_{t+1}] + E_t[\hat{\zeta}_t - \hat{\zeta}_{t+1}], \tag{38}$$

where $\Theta_n = \frac{\lambda\gamma_r\varphi}{(1-\gamma_r\lambda)}$, $\Theta_\upsilon = \frac{\gamma_r\lambda(1-\chi)}{(1-\chi+\upsilon)(1-\gamma_r\lambda)}$, $\iota^C \equiv \frac{\bar{\tau}^C}{(1+\bar{\tau}^C)}$, $\varphi = \frac{\bar{N}}{1-\bar{N}}$, $\gamma_r = \frac{\upsilon}{1-\chi+\upsilon}\frac{1}{1-\bar{N}}$, and we have used the fact that, in the steady-state, $\bar{R} = \beta^{-1}$. Note that $\Delta\hat{N}_{t+1} = \hat{N}_{t+1} - \hat{N}_t$ and so on. Under perfectly competitive labor markets, the wage evolution (labor supply schedule) is given by

$$\hat{w}_t = \hat{C}_t + \varphi\hat{N}_t + \iota^d\hat{\tau}^d_t + \iota^C\hat{\tau}^C_t + \hat{\upsilon}_t, \tag{39}$$

where $\iota^d \equiv \frac{\bar{\tau}^d}{(1-\bar{\tau}^d)}$. Calculations can also be retraced in Appendix C.

Fiscal authorities: Log-linearizing the normalized budget constraint, equation (24) around its steady-state yields

$$b_{t+1} - \beta^{-1}b_t = \gamma_G \underbrace{\left[\hat{G}_t - (\hat{\Psi}_t - \hat{P}_t)\right]}_{=Primary\ Deficit} + \bar{\tilde{b}}\underbrace{\left(1-\beta^{-1}\right)}_{<0}\left[\hat{\Psi}_t - \hat{P}_t\right] + \bar{\tilde{b}}\beta^{-1}\left[\hat{R}_{t-1} - \hat{\pi}_t\right]. \tag{40}$$

Equation (40) determines the evolution of the level of debt after a deviation of other the parameters. Real government revenues evolve according to

$$\hat{\Psi}_t - \hat{P}_t = \underbrace{\frac{\bar{\tau}^L\bar{W}\bar{N}}{\bar{\Psi}}}_{=Rev^L}\left(\hat{\tau}^L_t + \hat{W}_t + \hat{N}_t\right) + \underbrace{\frac{\bar{\tau}^C\bar{P}\bar{C}}{\bar{\Psi}}}_{=Rev^{VAT}}\left(\hat{\tau}^C_t + \hat{C}_t\right), \tag{41}$$

where

$$Rev^L = \frac{\bar{\tau}^L(\epsilon-1)}{\epsilon(1+\bar{\tau}^w)[\gamma_G - (1-\beta^{-1})\bar{\tilde{b}}]}$$

is the percentage of labor tax revenue and

$$Rev^{VAT} = \frac{\bar{\tau}^C}{\gamma_C[\gamma_G - (1-\beta^{-1})\bar{\tilde{b}}]}$$

the percentage of value added tax revenue calculated in deep parameters, with $Rev^L + Rev^{VAT} = 1$ (see Appendix E for more details). Equation (41) determines the deviation of government revenue from its steady-state value.

Log-linearized government spending is given by

$$\hat{G}_t = \frac{(1-\beta^{-1})}{\gamma_G} b_t - \frac{\rho}{\gamma_G} \cdot ac_{t-1} + \frac{1}{\gamma_G \bar{P}\bar{Y}} \cdot \nu_t + \frac{\bar{\bar{b}}(1-\beta^{-1})}{\gamma_G} \hat{\pi}_t - \beta^{-1} \frac{\bar{\bar{b}}}{\gamma_G} \hat{R}_{t-1} + \frac{\gamma_G - (1-\beta^{-1})\bar{\bar{b}}}{\gamma_G} \underbrace{\left[\varnothing_1 \cdot \underbrace{E_{t-1}\left\{\hat{\Psi}_t - \hat{P}_t\right\}}_{Balanced\ Budget} - \alpha \cdot \underbrace{E_{t-1}\left\{\hat{Y}_t\right\}}_{Automatic\ Stabilizer} \right]}_{=0\ for\ Debt\ Brake}, \quad (42)$$

while the log-linearized adjustment account is given by

$$ac_t = (1-\rho)ac_{t-1} + \frac{\nu_t}{\bar{P}\bar{Y}} + \left(\gamma_G - (1-\beta^{-1})\bar{\bar{b}}\right) \left[\left(\varnothing_1 \cdot E_{t-1}\left\{\hat{\Psi}_t\right\} - \varrho \hat{\Psi}_t \right) - \left(\varnothing_1 \cdot E_{t-1}\left\{\hat{P}_t\right\} - \varrho \hat{P}_t \right) - \alpha \left(E_{t-1}\left\{\hat{Y}_t\right\} - \hat{Y}_t \right) \right], \quad (43)$$

where $\varnothing_1 = \alpha = 0$ and $\varrho = 1$ for the debt brake, $\varnothing_1 = \varrho = 0$ and $\alpha > 0$ for the automatic stabilizer and $\varnothing_1 = \varrho = 1$ and $\alpha = 0$ for the balanced budget rule for both equations (42) and (43). Note, again, that $\hat{\pi}_t = \hat{P}_t - \hat{P}_{t-1}$. All the calculations regarding fiscal authorities can be retraced in Appendix D.

Monetary authorities: We assume that monetary authority acts as (exogenously) given by the following simple Taylor rule,

$$\hat{R}_t = (1-\mu)\left[\phi_\pi \hat{\pi}_t + \phi_Y \hat{Y}_t\right] + \mu \hat{R}_{t-1} + z_t, \quad (44)$$

where ϕ_π and ϕ_Y denote the reaction coefficients towards inflation and output deviations, respectively. μ denotes the degree of interest rate smoothing. z_t defines the monetary shock.

Market clearing: Market clearing implies that

$$\hat{Y}_t = \gamma_C \hat{C}_t + \gamma_G \hat{G}_t, \quad (45)$$

where γ_C and γ_G are the shares of output devoted to private and public consumption, respectively. They can be expressed in terms of deep parameters (see Appendix E).

Additional feedback and shocks: We further assume that there may exist an additional feedback of debt to tax rates in order to generate existence. This implies that we assume $\hat{\tau}_t^C = \chi_C b_t$, $\hat{\tau}_t^w = \chi_w b_t$ and $\hat{\tau}_t^d = \chi_d b_t$. Note that, except for the automatic stabilizer, we are able to set $\chi_k = 0$, where $k = C, w, d$ (see section 3 for a more detailed discussion). For the shocks we assume autocorrelation implying $\zeta_t = \rho_\zeta \cdot \zeta_{t-1} + \tilde{\zeta}_t$, $A_t = \rho_A \cdot A_{t-1} + \tilde{A}_t$, $\epsilon_t = \rho_\epsilon \cdot \epsilon_{t-1} + \tilde{\epsilon}_t$, $\upsilon_t = \rho_\upsilon \cdot \upsilon_{t-1} + \tilde{\upsilon}_t$, $z_t = \rho_z \cdot z_{t-1} + \tilde{z}_t$, $\nu_t = \rho_\nu \cdot \nu_{t-1} + \tilde{\nu}_t$ and $\xi_t = \rho_\xi \cdot \xi_{t-1} + \tilde{\xi}_t$, where $\tilde{\zeta}_t, \tilde{A}_t, \tilde{\epsilon}_t, \tilde{\upsilon}_t, \tilde{z}_t, \tilde{\nu}_t$ and $\tilde{\xi}_t$ are random i.i.d. shocks.

Proposition 1. *All endogenous macro-variables and, thus, welfare can be expressed by deep parameters and fixed levels of tax rates $\bar{\tau}^w$, $\bar{\tau}^d$ and $\bar{\tau}^C$ in the steady-state and are identical across all fiscal regimes considered.*

Proof. See Appendix E. □

Proposition 1 states that the steady-state levels of all variables are identical across fiscal regimes. This is of utmost importance for our welfare exercise as it allows us to focus on the business cycle implications of fiscal policy, whereas we do not need to adjust our conclusions for differences in the steady-states.

3 Calibration and Impulse Response Analysis

In this section we provide details on the business cycle dynamics if fiscal authorities implement the fiscal rules discussed above.

3.1 Calibration Strategy

While conducting the calibration exercise of the deep parameters we rely on parameter values typically recommended to describe the euro area.

For fiscal authorities we set in particular tax rates such that they reflect average tax rates on labor and value added typically reported. The labor tax rate was set to $\bar{\tau}^d = 0.125$, which includes labor income tax and the social security contributions of households. The steady-state rate of social security contributions of firms was set equal to $\bar{\tau}^w = 0.125$. The consumption tax rate is calibrated to be $\bar{\tau}^C = 0.183$. This endogenously determines the private consumption to output ratio and the government consumption to output ratio which are equal to $\gamma_C = 0.67$ and $\gamma_G = 0.33$.[4]

For the fraction of liquidity constraint consumers we choose $\lambda = 0.33$, which engineers a more moderate crowding out of private consumption to a highly autocorrelated exogenous expenditure shock on impact. For moderately autocorrelated spending shocks, it is able to replicate a crowding-in of private consumption, which is in line line with evidence reported from a VAR by Gali et al. (2007). For lower values of λ as, for instance, proposed by Coenen et al. (2008), our model would still predict a substantial crowding out in private

[4]Coenen et al. (2008) propose instead to set tax rates equal to marginal rates. Although appealing at first sight this would inflate the endogenously determined government to output ratio beyond 0.4 in our model.

consumption which might be considered as counterfactual (see Figure 1 which pictures the impulse responses for a fiscal spending shock with parameters set according to the baseline calibration and autocorrelation coefficient for the shock set equal to $\rho_\nu = 0.5$).

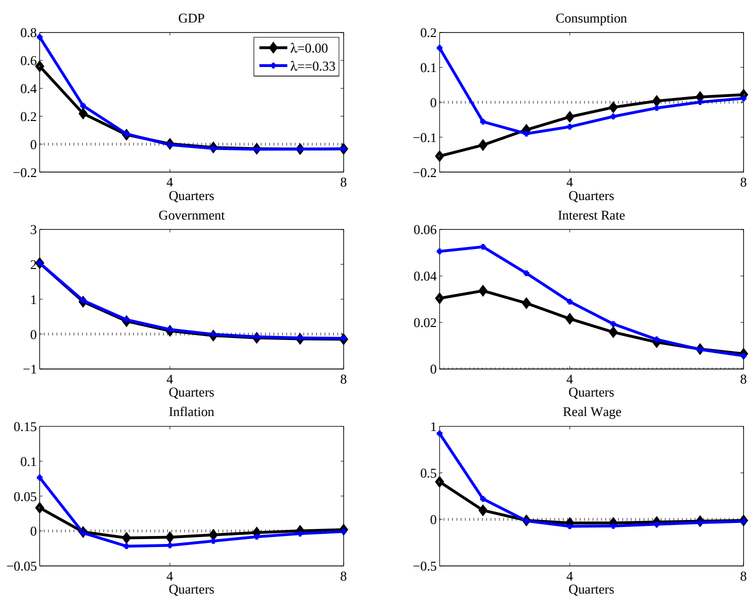

Figure 1: Government expenditure shock

Since we do not have a distinctive imagination for appropriate numerical values for ρ, which governs the partial feedback from the adjustment account to expenditures and for χ_j, where $j = C, d, w$, which governs the feedback from changes in public debt to tax rates, we choose the parameters such that our welfare metric was minimized. We find in particular that for all shocks except government expenditure shocks the algorithm preferred rather small parameters for ρ and χ_j. Accordingly, we set $\rho = 0.05$, which generates a unique and determined rational expectations equilibrium. In section 5.1, we provide some further discussion on the role of ρ for a welfare enhancing design of a debt brake. We are able to set $\chi_j = 0$. This is advisable as it allows us to eliminate movements in distortionary taxes on labor and value added at the business cycle frequency. Note however, as we will discuss below, we need some moderate feedback of taxes to changes in debt for an automatic stabilizer to output to prevent the equilibrium to be non-unique.

For the supply side of the model to imply a substantial degree of nominal rigidities we set $\theta_p = 0.75$, which implies that prices are fixed on average for four quarters. This is calibrated somehow in the middle of the range typically reported in literature. Coenen et al (2008) and Smets and Wouters (2004) estimate an average price duration for optimal price setting of ten quarters using full information Baysian estimation techniques, while Del Negro et al. (2005)

only report an average price duration of three quarters. Micro-data for the euro-area on price setting report low price durations with a median of around 3.5 quarters (see Alvaraez et al., 2006 for a summary of recent micro-evidence). The steady-state mark-up of intermediate good producers over marginal cost is set at 10 per cent, implying that $\epsilon = 11$.

As we have modelled the household sector by a log-log specification for analytical convenience, the implied intertemporal elasticity of substitution is equal to $\sigma = 1$. Following Gali et al. (2004), who specify the household sector in a similar setting, we calibrate the inverse of the Frisch elasticity of labor supply equal to $\varphi = 1$. This, in turn, implies that the steady-state per capita consumption ratio of liquidity constraint to average consumers is equal to $\gamma_r = \bar{C}^r/\bar{C} = 0.8$. The discount factor is fixed to $\beta = 0.99$, implying a 4% steady-state real interest rate.

The Taylor-rule coefficients display the familiar values. The inflation coefficient on the inflation rate was set to $\phi_\pi = 1.9$ while for the output gap coefficient we opt for $\phi_Y = 0.25$ (see Del Negro et al., 2005; Coenen et al., 2008; and Smets and Wouters, 2003). Following Gali et al. (2004), we set the inflation coefficient to a somewhat higher value than originally proposed by Taylor (1993) as, in the light of rule-of-thumb consumers, the central bank is forced to follow a more anti-inflationary policy. The interest rate smoothing coefficient was set to $\mu = 0.85$.

The exogenous driving forces ζ_t, A_t and ϵ_t are assumed to follow a univariate autoregressive process where the first order coefficients where set as follows: $\rho_\zeta = 0.882$, $\rho_\epsilon = 0.890$ and $\rho_A = 0.822$. These values reflect coefficients found in Coenen et al. (2006) and Smets and Wouters (2003, 2007). For the case of the exogenous fiscal spending shock, the recent literature has not yet found a clear cut consensus. While some authors report evidence for highly auto-correlated fiscal expenditure shocks such as Smets and Wouters (2004) with $\rho_\upsilon = 0.956$ among others. Chari et al. (2007) attribute only little role to fiscal expenditure shocks at all. Still, others estimate DSGE models and remain tacit whether there is any role for fiscal expenditure shocks by not specifying them (Coenen at al., 2008).

3.2 Impulse Response Analysis

Given the above calibration we kick off to analyze the different sets of fiscal policy rules. In this section the emphasis is on the identification of distinct differences across fiscal regimes following a shock to consumer preferences and to a price mark-up shock. In section 4, we will draw welfare conclusions.

Shock to consumer preferences

Figure 2 portrays the dynamic response of selected variables to a shock to consumer preferences if fiscal policy follows a debt brake.

Due to the additional demand posted to firms those firms that are allowed to reset prices increase prices to cushion the increasing marginal cost pressure stemming from higher wages

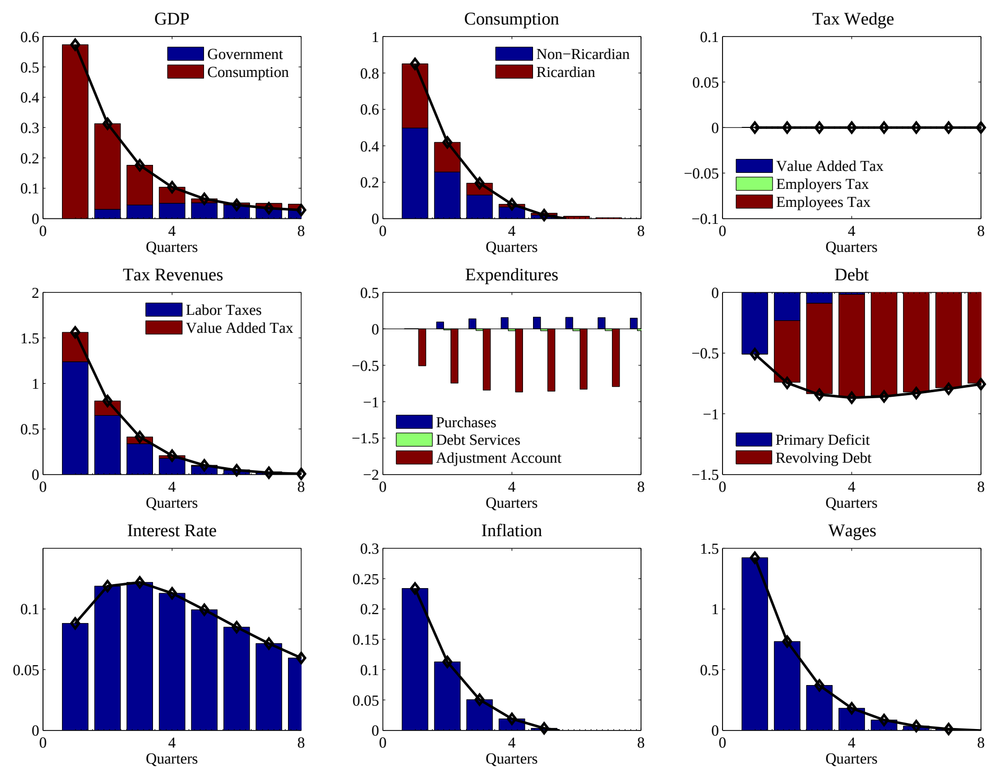

Figure 2: Debt Brake and Consumer Preference Shock

to incite households to work more in order to satisfy the additional demand. The increase in real wages, in turn, encourages Non-Ricardian consumers to increase their consumption expenditures. Although they only account for one third of the household sector they drive, on impact, almost 50% in the consumption dynamics and start to dominate the picture onward. As monetary authorities are determined to dampen inflation variability they increase real interest rates and slowdown consumption expenditures such that inflation falls quickly. The somewhat tough stance on inflation and the implied high interest rate along the adjustment path almost completely wipes out the positive impact of the consumer preference shock for Ricardian households from quarter three onwards. The impulse responses portray that fiscal authorities keep expenditures largely stable over the cycle. In particular the additional funds raised due to an increase in labor and consumption taxes are not spent but pathed through to debt. Thus the debt brake embodies automatic stabilization on the revenue side as government expenditures are decoupled from cyclical movements in revenues and kept at trend. The mildly pro-cyclical movement in government expenditures can be attributed to interest rate payments on outstanding debt and the commitment of fiscal authorities to keep overall debt constant in the long run, which means that the additional funds are spent gradually over time. This is engineered by a low feedback from the adjustment account to government expenditures.

Figure 3 depicts the business cycle dynamics if fiscal authorities are determined to balance the budget in each period. Due to the planning horizon of one period the budget will not balanced in the first period as the unexpected tax revenues are not accounted for in the predetermined government expenditure plans. The regime shift leads to a number of remarkable changes in the business cycle. First, government expenditures become quantitatively the driving component of GDP, whereas for the debt brake, private consumption expenditures dominated the picture over the first five quarters. From period two onward, the government spends the additional tax revenues which has two effects on the economy. On the one hand, firms have to pay significantly higher wages to optimizing households to extent their hours worked, while, on the other hand, the significantly higher wages lead to a boom in consumption among liquidity constraint consumers. Accordingly, compared to a debt brake, we observe a somewhat higher inflation rate and higher interest rates, which almost completely crowd out the consumption expenditures of Ricardian households. The low feedback running from the partial adjustment account to expenditures gradually reduces the debt accumulated in the first period due to the expectations error.

Figure 4 illustrates the response to a consumer- preference shock if the government tries to implement a debt brake but explicitly allows for automatic stabilization in output (which we have termed "automatic stabilizer"). In the upper panel, we plot the tax wedge. It serves as a measure for the cumulative distortions imposed on the economy due to movements in tax rates at the business cycle frequency. Following Coenen et. al (2007), it is measured as follows: Define the real effective wage income of households as $\frac{(1-\tau_t^d)}{(1+\tau_t^C)}\frac{W_t}{P_t}$ and the effective labor cost of firms as $(1+\tau_t^w)\frac{W-t}{P_t}$. In an undistorted equilibrium, the ratio of the two would

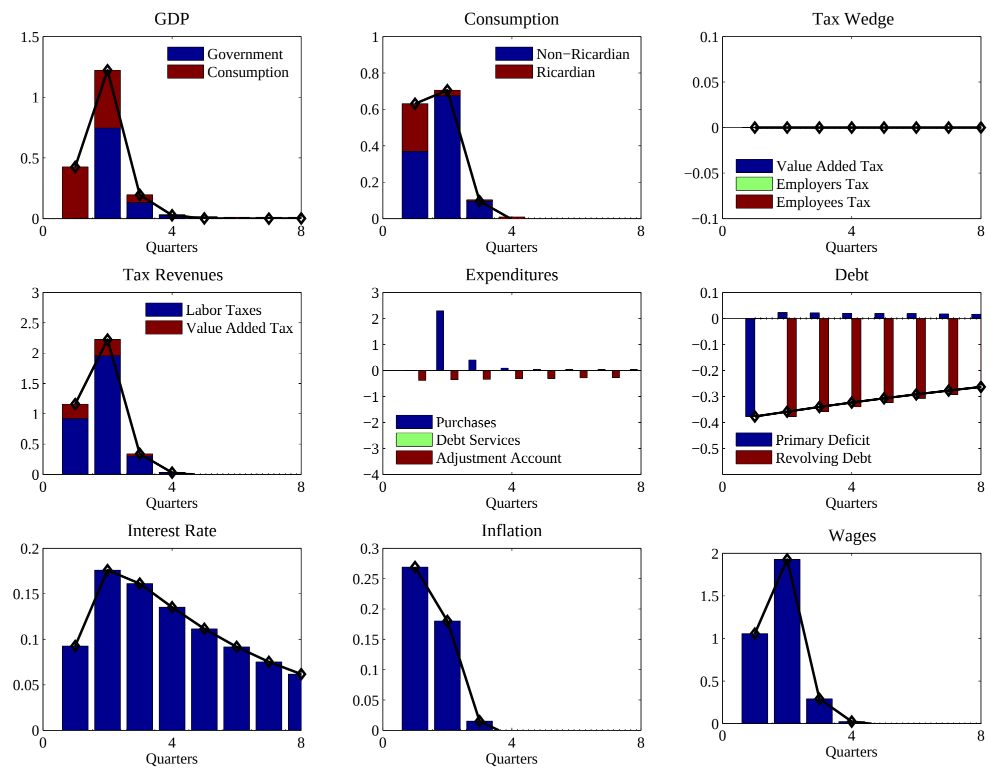

Figure 3: Balanced Budget and Consumer Preference Shock

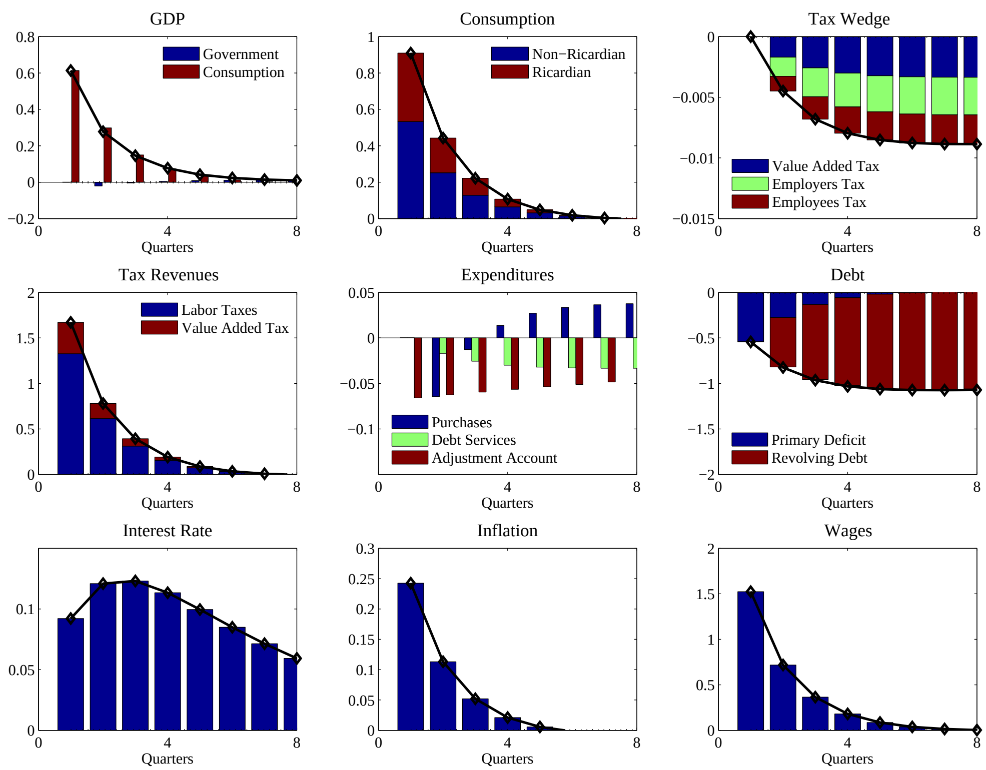

Figure 4: Automatic Stabilizer and Consumer Preference Shock

be one. Accordingly,

$$\tau_t^{wedge} = 1 - \frac{(1-\tau_t^d)}{(1+\tau_t^C)(1+\tau_t^w)}$$

serves as a summary statistic to measure the evolution of the tax wedge over the cycle. A distinct difference of the automatic stabilizer regime to the two previous regimes stems from the need to design a feedback from tax rates to changes in government debt. Without this feedback, the moderate cut in government spending due to the feedback from the adjustment account to real government expenditures would not be sufficient to stabilize the net present value of outstanding real government liabilities and, thus, generate explosive equilibria. As for the case of a debt brake, the additional revenues are not spent but passed through to debt. Because the government needs to rely on pro-cyclical taxation, the surpluses in revenues quickly vanish and debt starts to return gradually to its initial steady state. Generally, the effects are very similar to those of the debt brake. However, note that, for the automatic stabilizer, government spending acts very mildly counter-cyclical (or, basically, stays constant), while it is mildly pro-cyclical for the debt brake.

Shock to price mark-up

Figure 5 illustrates the course of business cycle dynamics if the economy is hit by a persistent shock to the price mark-up. Those firms who can reset prices adjusts prices upward as market power has risen. Monetary authorities increase real interest rates to set incentives to Ricardian households to reallocate planned consumption expenditures into the future. This depresses contemporaneous aggregate demand such that firms have to engineer cuts in production by offering lower real wages. As consumption expenditures of Non-Ricardian households are driven by real wages, the downturn of the economy is accelerated.

If fiscal authority's implement a debt brake, the basic operating principles are identical to those observed for the case of a demand shock. The cyclical shortfall in revenues does not trigger cuts in government expenditures but is absorbed by debt. This builds in an automatic stabilization mechanism for the evolution of GDP as government expenditures move mildly but persistently pro-cyclical. This pro-cyclical behavior stems from debt services and more moderate fiscal expenditure from quarter two onward as the government is committed towards keeping the steady state debt to GDP ratio constant over time.

Figure 6 depicts the course of the economy if fiscal authorities are committed towards a balanced budget. It prevails that the basic operating principles are comparable to the case of a shock to consumer preferences. The deterioration of the tax base during the economic downturn forces cuts in expenditures from quarter two onward. This amplifies the economic downturn, in particular, as Non-Ricardian households sharply cut their expenditures because real wages decline more pronounced than under a debt brake regime. The fiscal contraction helps somewhat to relieve the economy from inflationary pressure such that the increase in real interest rates is more moderate as it would be if fiscal authorities kept the expenditure stream at trend.

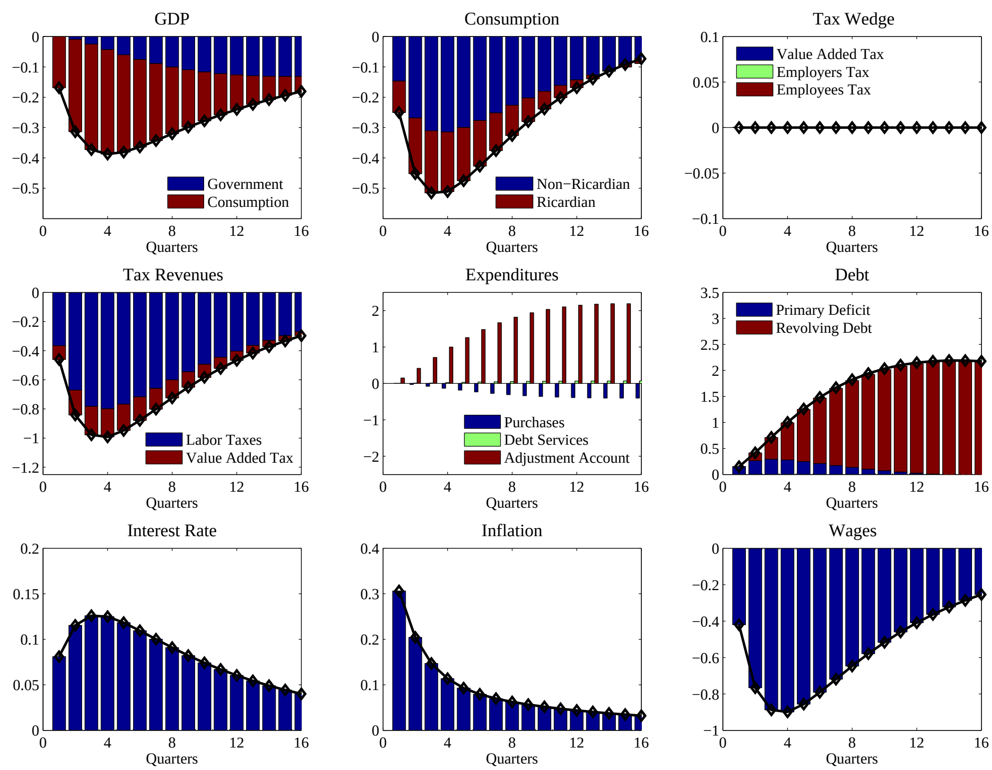

Figure 5: Debt Brake and Price Mark-Up Shock

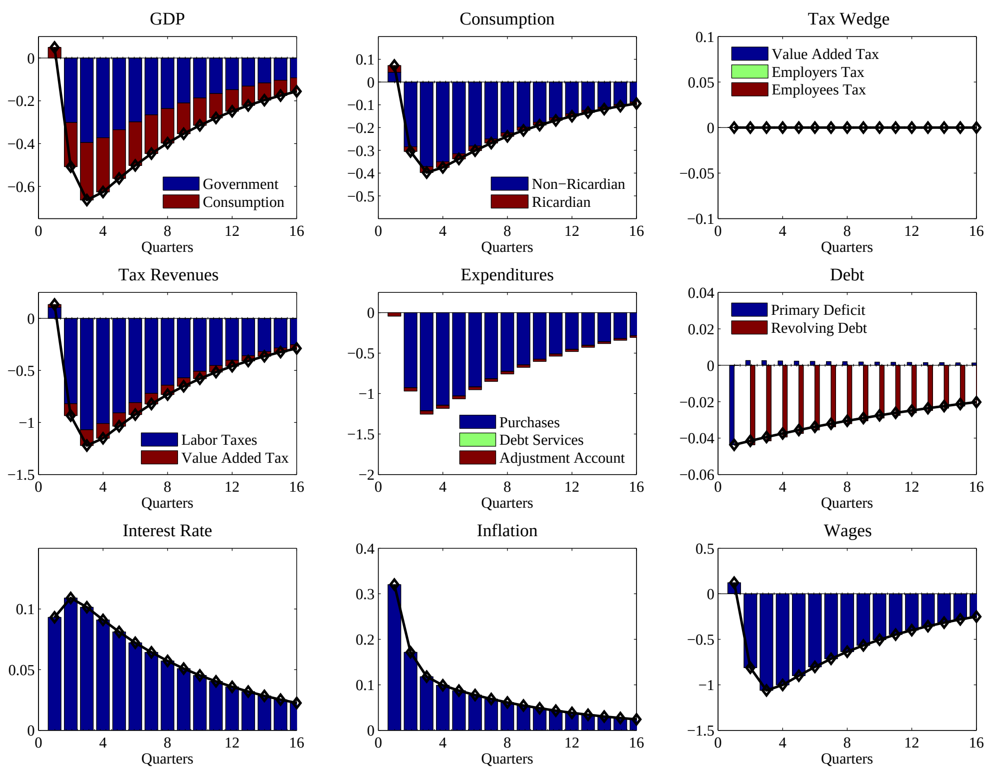

Figure 6: Balanced Budget and Price Mark-Up Shock

Figure 7 portrays the dynamics of the business cycle if fiscal authorities implement an automatic stabilizer. For the case of a price mark-up shock, this regimes turns out to be the most passive one in terms of fiscal expenditures because the counter-cyclical stance due to automatic stabilization in output and the need to bring back real debt in the medium term chancel out. Hence, government expenditures are effectively kept constant. Consequently, fiscal authorities are less ambitious to reverse debt dynamic which prevail more persistence. As beforehand a sufficiently strong pro-cyclical movement in tax rates is a necessary condition to revert debt dynamics and anchor the outstanding real government liabilities. As tax rates are increased, tax revenues are at their trend level after four quarters. The dynamics of the inflation rate and wage dynamics are similar as those observed under a debt break.

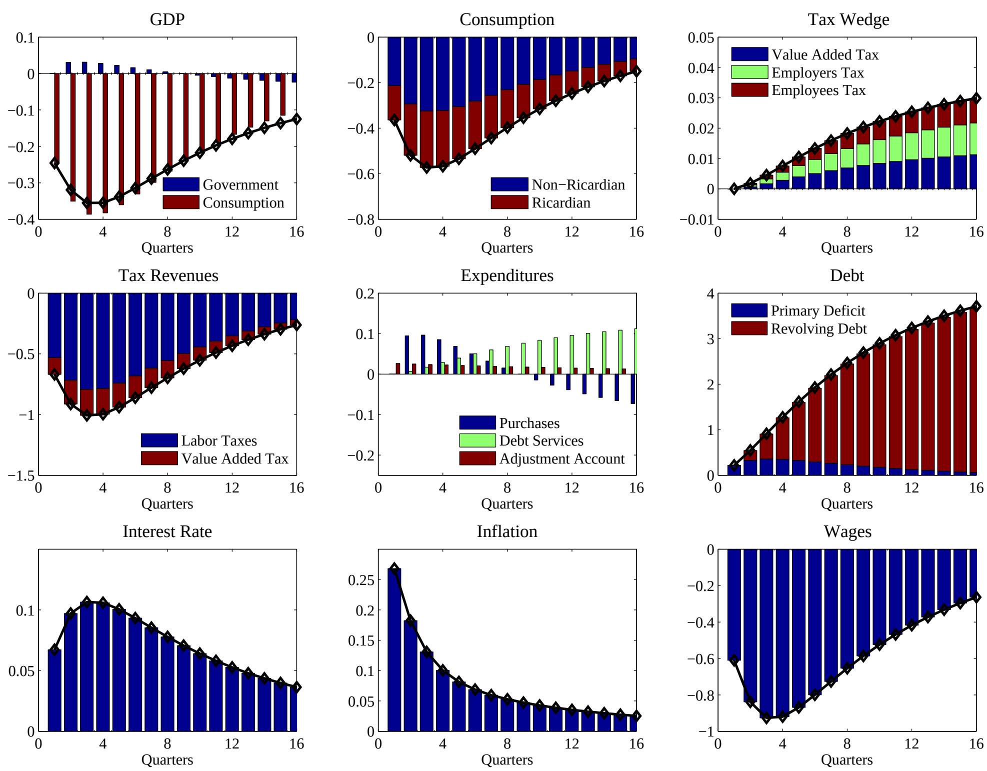

Figure 7: Automatic Stabilizer and Price Mark-Up Shock

Shock to technology

Figure 8 portrays the course of the business cycle dynamics if the economy is hit by a technology shock under a fiscal debt brake regime. The technology shock augments productivity and, thus, cuts marginal costs of firms. For a given level of output, this allows firms to cut employment or augment production for a given level of employment. In order to cut employment, firms reduce wages, which decreases labor supply and consumption of Ricardian households. As marginal costs and wage costs decrease, those firms that can reset their prices to a lower level, which decreases inflation. The fall in inflation makes the central bank cut interest rates, which, in turn, augments consumption of Ricardian households. In total, consumption rises. Higher demand for goods implies that additional production is needed and, therefore, firms raise wages from period three onward to also make Non-Ricardian households supply more labor, which, then, increases their consumption level. The rise in consumption and output then drive inflation back to its original level. Following the debt brake, the government basically keeps expenditures fixed to trend revenues and passes the fall in true revenues to debt, which, as in the other cases, yields a very mild counter-cyclical spending behavior due to the interest payments.

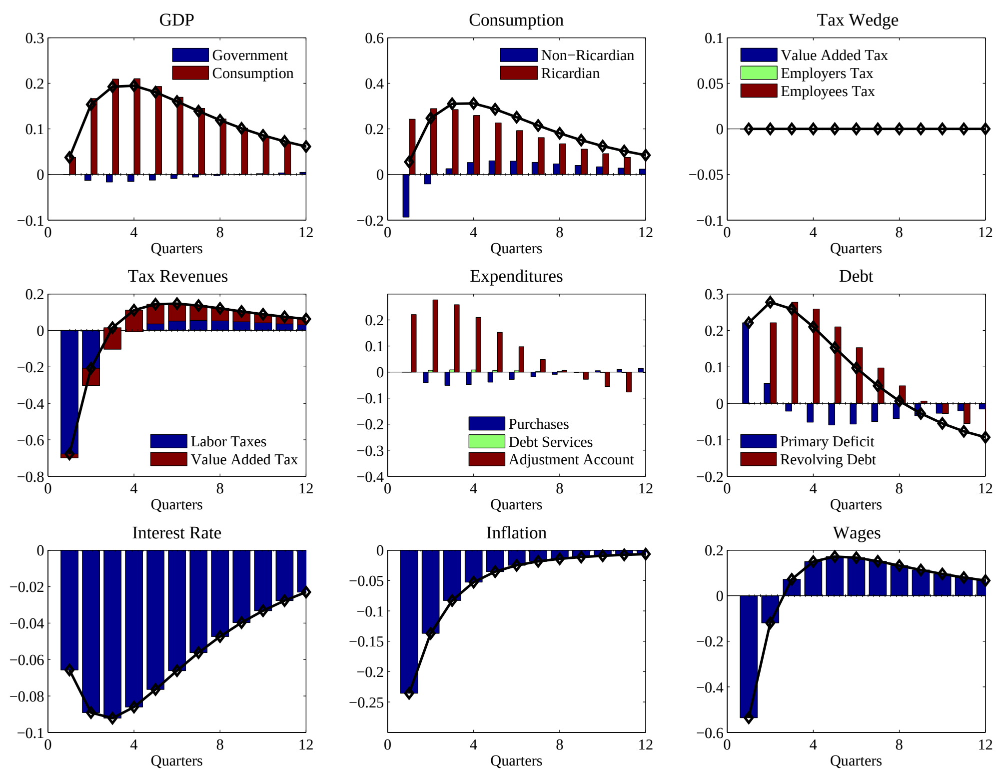

Figure 8: Debt Brake and Technology Shock

In figure 9, we see how the business cycle dynamics change whenever the government follows a balance budget rule. In the first period, the decrease in revenues, mainly due to labor taxes because of lower wages and less labor supply, is not anticipated by the government and passed though to debt because of the planning horizon. However, in the second period, we see, in contrast to the debt brake regime, a sharp decrease in government expenditure mainly resulting from the balanced budget requirement. As the demand from the government decreases, this dampens GDP and yields a further decrease in wages, again, lowering consumption of Non-Ricardian households. In a certain way, this could be interpreted as a negative government spending shock. This is, in total, not able to compensate for the increase in consumption of Ricardian households resulting from the interest rate decrease due to less inflation. From period three onward, tax revenues increase due to higher value added taxes from more aggregated consumption, which boosts government expenditure and output. Due to the rise in output, wages have to rise in order to augment labor supply. In total, we see that the balanced budget regime generates much more fluctuations in government spending and also other macroeconomic variables.

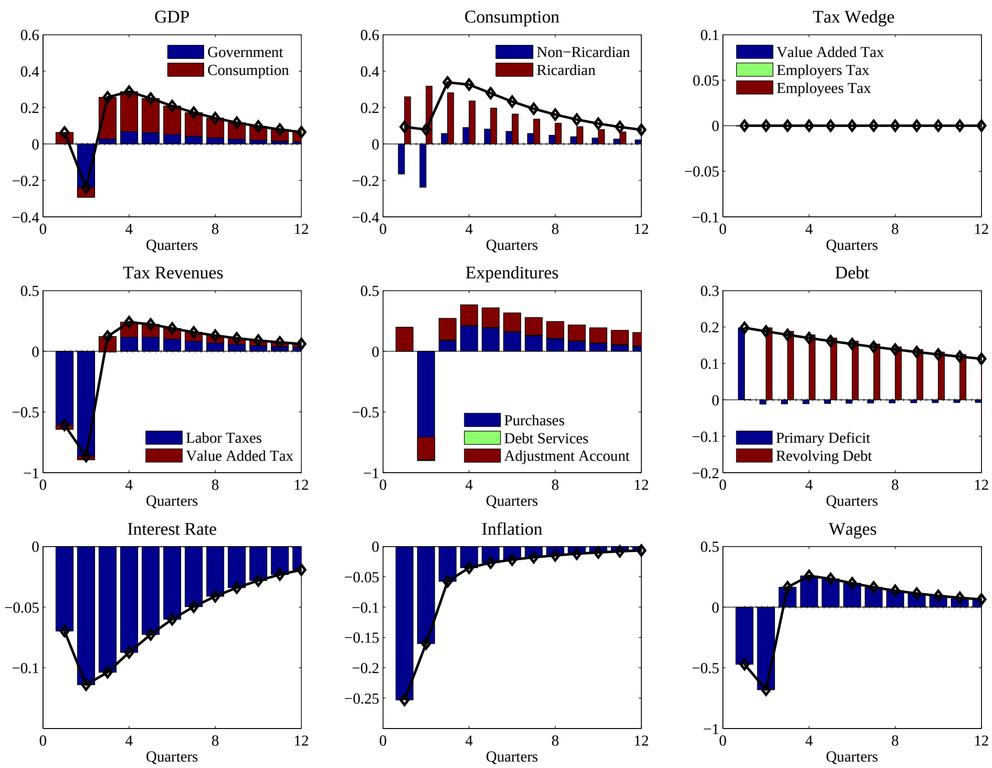

Figure 9: Balanced Budget and Technology Shock

Figure 10 illustrates the business cycle dynamics under an automatic stabilizer regime. We see that, in principle, it is quite similar to the debt brake regime. However, the countercyclical government expenditure reaction is more pronounced and, as for the other regimes, we need a small feedback between taxes and debt to achieve a stable equilibrium. Government expenditures move slightly counter-cyclical, mainly driven by the counter-cyclical component of the debt brake as hardly anything that is booked on the adjustment account affects government spending. From period three onward, the higher demand for goods and output makes firms rise wages to generate higher labor supply, which augment government revenue. These extra revenues are, basically, fully passed into debt which falls stronger than in the case of the debt brake. Still, government spending stays low as the counter-cyclical component is not compensated by the reduced debt services (more precisely, the additional income resulting from negative levels of debt).

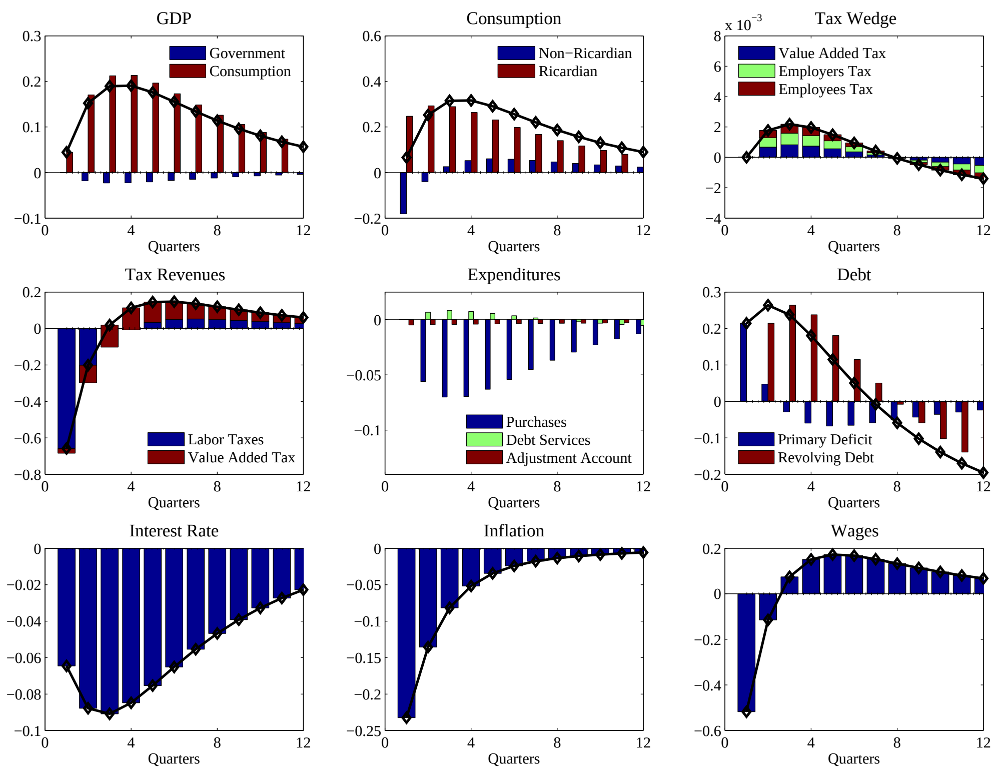

Figure 10: Automatic Stabilizer and Technology Shock

4 Welfare

As shown in Appendix F, the welfare criterion is derived by a second-order approximation of the average utility of a household around the deterministic long-run steady state. The welfare function can be written as follows (see also Erceg, Henderson, and Levine, 2000; Gali and Monacelli, 2007; and Woodford 2003)

$$\begin{aligned}\mathbb{W}_0 = E_0 \sum_{t=0}^{\infty} U_t &= \sum_{t=0}^{\infty} \left(\frac{(1+A_1)}{2} \left[(1+\hat{Y}_t)^2 - (\hat{Y}_t - \hat{\zeta}_t)^2 \right] - \frac{\varphi}{2\gamma_o} \left[\hat{Y}_t^2 - (\hat{Y}_t - \hat{\upsilon}_t)^2 \right] \right) \\ &\quad - A_1 \cdot \frac{\epsilon}{\kappa} \sum_{t=0}^{\infty} \beta^t \hat{\pi}_t^2, \end{aligned} \tag{46}$$

where $-1 < A_1 = \left((1-\gamma_G)\lambda \frac{1-\gamma_r}{1-\gamma_r \lambda} \varphi - \frac{\upsilon}{\gamma_o} \varphi \right) < 0$. Next, we characterize the welfare implications of the different fiscal policy regimes by means of numerical analysis for five types of shocks, namely shocks to consumer preferences, shocks to the price mark-up, transitory technology shocks, monetary shocks and fiscal spending shocks. For the baseline calibration, more than 90% of the welfare losses are driven by technology, cost-push and consumer preference shocks, as shown in Figure 17. Therefore, we only discuss these three shocks in turn before presenting the overall welfare statistics.

Figures 11 to 13 plot the adjustment path of the inflation rate (which dominates the welfare metric in the upper panel) for the different fiscal policy regimes under consideration and the response of fiscal authorities under the different regimes in the lower panel for a consumer preference shock, a cost push shock and a technology shock, respectively. As a reference point we additionally report how a discretionary optimizing fiscal authority that responds to the predetermined state variables $\hat{\zeta}_t$, $\hat{\epsilon}_t$, $\hat{A}_t$ and b_{t+1} behaves by implementing the following rules

$$\hat{G}_t = -13.44_{(6.23)} \cdot \hat{\zeta}_{t-1} - 0.34_{(0.07)} \cdot b_t, \tag{47}$$

$$\hat{G}_t = -60.56_{(7.03)} \cdot \hat{\epsilon}_{t-1} - 0.33_{(0.05)} \cdot b_t \tag{48}$$

and

$$\hat{G}_t = -7.71_{(0.41)} \cdot \hat{A}_{t-1} - 0.31_{(0.03)} \cdot b_t, \tag{49}$$

where the coefficients are chosen such that the welfare loss function, equation (46), is minimized. In order to give a fair comparison, we assume informational symmetry. This means that the optimizing fiscal policymaker can only observe the predetermined state variables with one period delay such that public expenditures are predetermined in the first quarter across all considered regimes. The following remarks summarize the main findings.

Remark 1. *All proposed simple fiscal policy regimes perform remarkably worse than an optimal discretionary fiscal policymaker that implements rules (47) to (49).*

The impulse responses illustrate that an optimal discretionary fiscal policymaker designs a negative correlation between the inflation rate and government expenditures. Such a contractionary policy stance is welfare enhancing. Accordingly, any policy measure which contributes to inflation stabilization increases welfare (see also the description of the business cycle dynamics in section 3.2). The reasons become obvious by inspection of equation (46), which states that inflation is the main contributor to aggregated welfare losses.

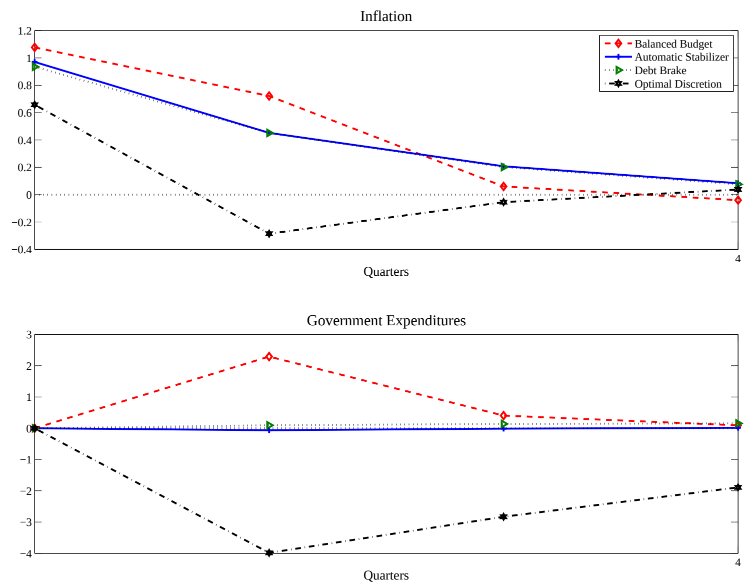

Figure 11: Shock to consumer preferences and welfare

Remark 2. *In particular, a balanced budget rule moves government expenditures pro-cyclical to inflation which aggravates the adverse welfare affects of price dispersion as it promotes a boom in overall consumption and (relatively) boosts inflation.*

In presence of the balanced budget rule, government spending, in principle, moves pro-cyclically with inflation, whereas the optimal response would be to move exactly in the opposite direction. An exception is the presence of a cost-push shock. In this case, as described in detail in Figure 6, tax revenues fall, which implies a fall in government spending when adapting the balanced budget rule (while the other rules imply a rather fixed spending path, see Figure 12). Note, however, that this is the only type of shock in which the balanced budget rule moves government spending in the right direction.

Remark 3. *The debt brake and the automatic stabilizer generally keep government spending stable and, thus, avoid to be a source of economic disturbance. They do a lot better than the balanced budget rule, namely* 15.4% *for the automatic stabilizer and* 11.4% *for the debt brake.*

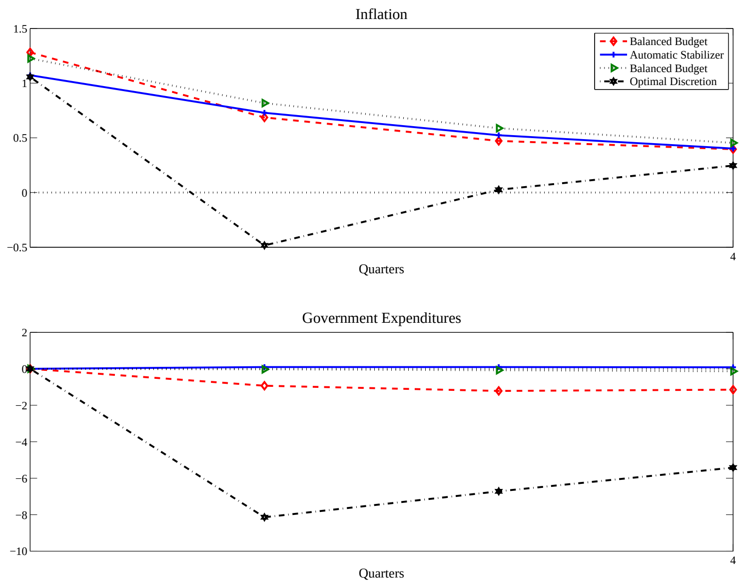

Figure 12: Cost push shock and welfare

As becomes clear by the description in section 3.2, government spending is more or less kept constant according to the debt brake and the automatic stabilizer (which is nothing but the debt brake with active built-in stabilization). Hence, the inflation dynamics are quite similar. Inspection of Figure 11 shows that, for a consumer preference shock, inflation dynamics are, on impact, a little lower for the debt brake than for the automatic stabilizer, while the opposite holds for the cost-push shock.

Is this evidence gained from Figures 11 to 13 robust? To discuss this issue we conduct a simple robustness exercise. Precisely speaking, we compute the expected value of the loss function, equation (46), for the debt brake and for a regime with automatic stabilization and the balanced budget and take the ratio of the two. If the ratio takes a value one, then the loss under a debt brake and the two alternative fiscal policy regimes would be identical. If the value of the ratio is above (below) one, then the loss under a debt brake is smaller (larger) than the loss under the alternative fiscal policy regimes. The two lines in Figure **??** indicate for a consumer preference shock, how the ratio changes when the deep parameters displayed at the top of the figure is altered, while the other parameters remain fixed at their baseline values.

The following results stand out. While the relative performance of the debt brake in comparison to a debt brake which builds-in an automatic stabilization remains somewhat constant over a wide range of parameters the relative performance of a balanced budget quite critically hinges on the concrete parameter constellation. It prevails in particular that for an increasing share of Non-Ricardian households the balanced budget regime does poorly

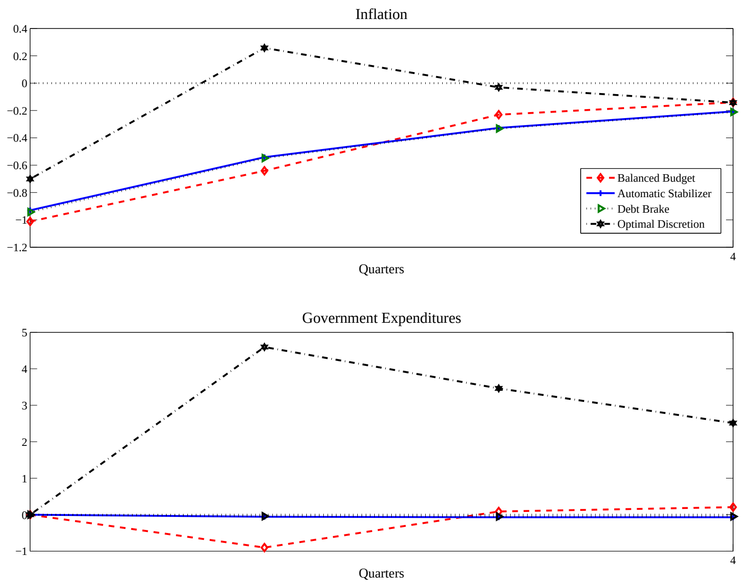

Figure 13: Shock to technology and welfare

and ultimately fails to generate a determinate equilibrium. With an increasing share of Non-Ricardian households monetary authorities loose their leverage on the intertemporal consumption decision of the average household, as documented by Gali et al. (2004). As a balanced budget regime generates larger amplitude in real wages this promotes a boom in consumption for rule of thumb consumers. If their share increases this will offset the drop in consumption of Ricardian households and ultimately destabilize the economy.

The robustness exercise indicates that the relative performance of the debt brake and the automatic stabilizer remain almost constant for increasing values of ϕ_π, while the balance budget still performs poorly. This reflects that a stronger stance on inflation generates higher real interest rates along the adjustment path such that given a constant share of Non-Ricardian consumer's consumption returns faster towards its steady state. This in turn moderates real wage claims and consumer spending among Non-Ricardian households such that the cycle will be less pronounced irrespectively of the fiscal policy regime.

Comparing the results for a cost push shock, we observe that the automatic stabilizer does better than the debt brake. This can be explained as follows: We observe in quarter one that consumption over both consumer types drops faster for the case of the automatic stabilizer. Accordingly, we observe a more pronounced cut in real wages which moderates the increase of the inflation rate and is thus welfare enhancing. Therefore inflation on impact is 10 percent lower than under a debt brake regime.

The economic mechanism which drives the result for a debt brake is explained by the mild but highly persistent movement in government expenditures. As we have shown be-

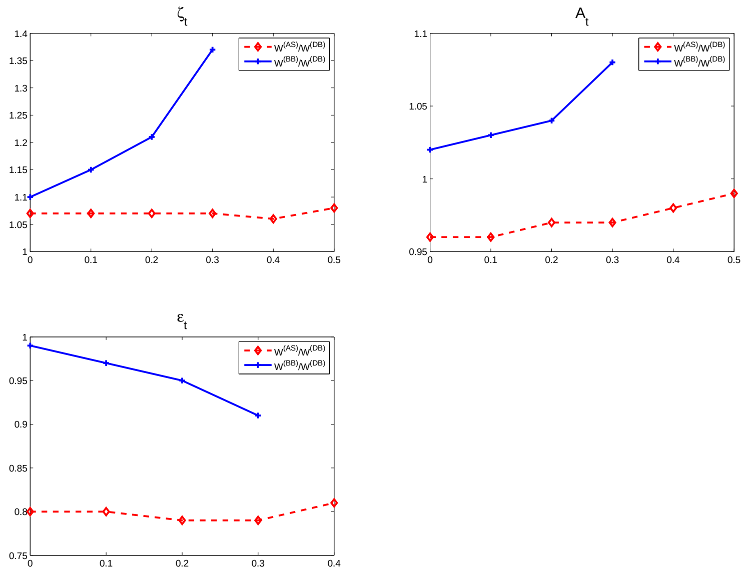

Figure 14: Robustness λ

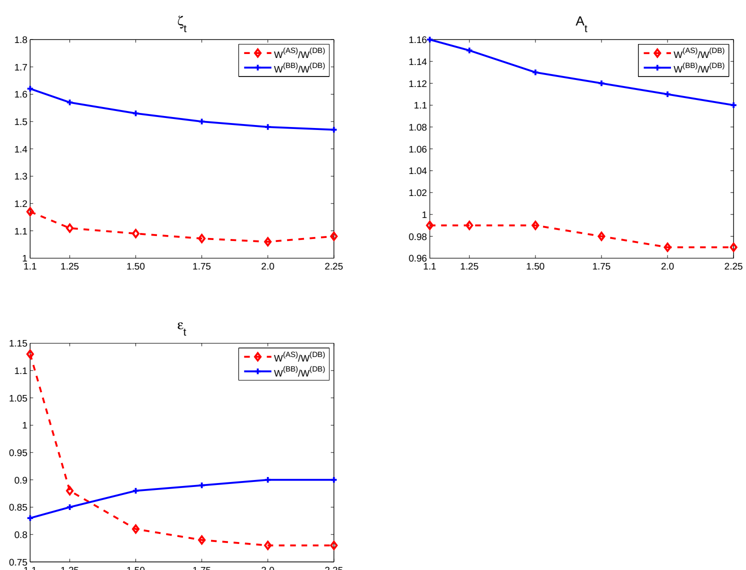

Figure 15: Robustness ϕ_π

fore, for the case of highly correlated shocks, movements in public expenditures lead to significant crowding out effects. Therefore the anticipation of a highly persistent cut in government expenditures crowds in consumption as the drop of consumption among non-Ricardian households is only moderate. The crowding in effect is driven by expectations of higher interest rates along the adjustment path on the behalf of monetary authorities. These crowding in effects retard the drops in GDP and accordingly of wages on impact. Only from period three onward, when the cuts in government expenditures actually materialize, the impulse responses among the two regimes start to converge.

In sum, the anticipation effect of highly correlated government expenditures, which only materialize in later periods, drive the differences in welfare results for a debt brake and an automatic stabilizer regime. As the anticipation of highly correlated government expenditures promotes a more moderate drop in wages this supports higher inflation rates and is in turn welfare reducing.

Welfare under the complete set of shocks: While we have focussed in the previous sections on the individual shocks and the economic mechanisms which drive the welfare results we now present as a summary statistic the overall welfare implications. Assuming that the economy is driven by a set of orthogonal shocks we can compute the welfare figures based on the findings for the individual shocks by just summing up the numbers.

As a summary statistic we find that the part of the welfare function that can be manipulated by fiscal authorities would increase by 11.42% if fiscal policy would switch from a debt brake towards a regime of a balanced budget. With respect to the automatic stabilizer it prevails that the overall welfare could be enhanced by 3.98%.

5 Design and stress testing

In this section, we will refer to some important issues that may arise when designing a debt brake. We do not claim completeness, however, think that the issues addressed below are of great importance.

5.1 How to set the feedback of the adjustment account

Thorough the last sections we have set $\rho = 0.05$, claiming that such a value is roughly welfare optimal. In this section we will verify this claim and make a proposition to install a two tired adjustment account framework as the fiscal shock calls for a rather high value of ρ, while for all other shocks it is advisable to set ρ to a small number, which still supports a determinate rational expectations equilibrium and anchors the real value of outstanding government liabilities.

Figure 16 illustrates which value of ρ would be optimal from a welfare perspective if it would be possible to fine tune ρ towards a specific shock. Precisely speaking we compute the ratio of the expected loss if we allow ρ varying from zero to one, while all other parameters remain fixed at their baseline calibration and take the ratio to the baseline where we have set ρ to 0.05.

Recall, if ρ is close to one fiscal authorities are forced to balance the adjustment account almost completely in the quarter following the laps, while ρ close to zero indicates a near random walk behavior of the adjustment account and only calls for gradually reductions in government expenditures over time.

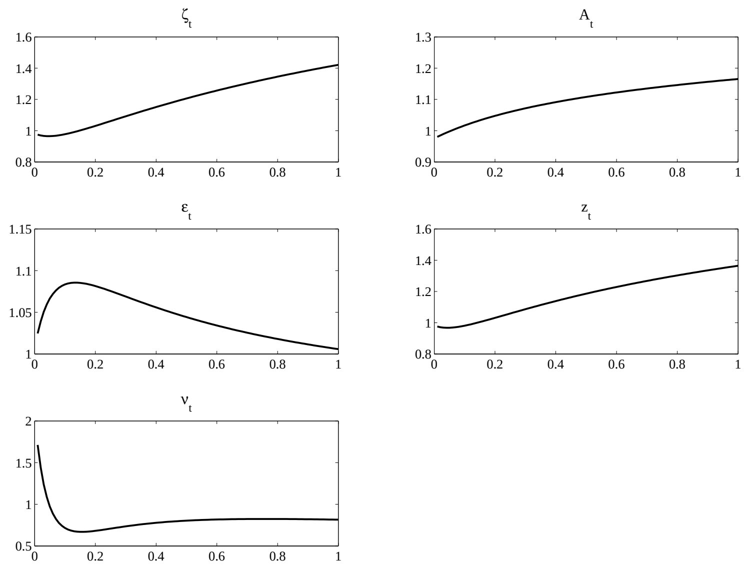

Figure 16: Optimal feedback coefficient for each shock

Figure 16 portrays that for the case of a shock to consumer preferences, to technology, to price mark- up and to the interest rate the optimal feedback value of ρ should be small. Thus, if the source of movements in the adjustment account can be traced back towards cyclical movements in government revenues that are related to fundamental shocks fiscal authorities are well advised not to correct fiscal expenditures to sharply in the previous period as this would work against the automatic stabilizer build in the debt brake.

For the case a fiscal shock itself the recommendation is completely reversed. If a fiscal policy shock is the source of movement in the adjustment account the welfare analysis reports clear evidence that a sharp correction in the following period is advisable. The optimal ρ is equal to 0.114, but significantly higher values also dramatically reduce the adverse welfare implications of fiscal spending shocks.

Figure 17 illustrates the percentage of welfare losses that are related to the specific shocks. The figure shows that for low parameters of ρ, say 0.01 fiscal spending shocks still drive round about 9 percentage point of the overall welfare loss, while for an optimal value of ρ fiscal

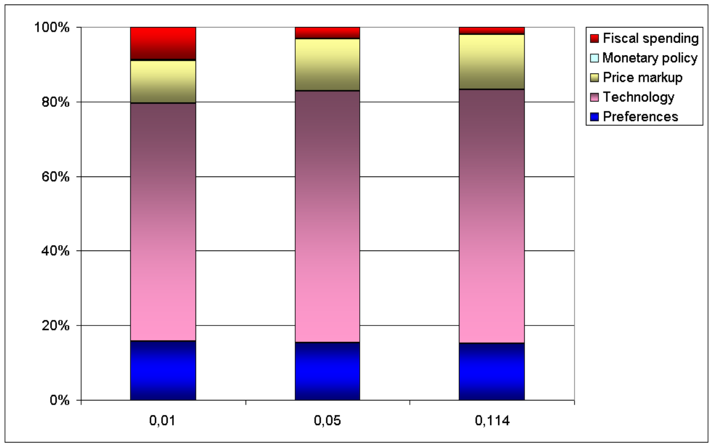

Figure 17: Loss decomposition

policy could be almost eliminated as a source of economic disturbances as only 1.88% of the overall welfare loss could then be traced back towards fiscal policy. Based on this analysis a two tired adjustment account system seems advisable. In one account the fiscal lapses would be booked while the other account would keep track of the rest. Such a system would allow designing a high feedback towards the adjustment account related to fiscal spending shocks and simultaneously a low feedback for the rest. This setting requires to be safeguarded by an institutional arrangement where a fiscal watchdog analysis and separates the lapses in time such that an appropriate feedback would materialize in the following period.

5.2 Trend estimation errors

In this section, we extent the setting derived in the previous parts of the paper to allow for measurement error on trend output on behalf of fiscal authorities. In practice, it prevails that governments are often subject to persistent measurement errors in trend output. Additionally, estimations vary according to who estimates the trend; further, there is quite a high frequency of trend revisions as time moves on.[5] For analytical simplicity and without loss of generality, we assume that $\bar{\tilde{b}} = 0$, i.e. we consider a zero debt economy. Reverting to equations (30) and (31), we can express the debt brake in presence of trend mis-estimations as

$$(R_{t-1} - 1)\tilde{b}_t + \frac{G_t}{\bar{Y}} = \underbrace{\frac{\bar{\Psi}}{\bar{P}\bar{Y}} \cdot E_{t-1}\{a_t\} - \rho \cdot \frac{P_{t-1}}{P_t} ac_{t-1}}_{=Rule\ based\ spending} + \frac{\nu_t}{P_t \bar{Y}},$$

[5]As Fritsche and Döpke (2006) put it, "*it [may] not always [be] advisable to listen to the majority of forecasters*". The issue of trend mis-estimation and its implications are briefly addressed within this section, but not in a very sophisticated manner as it is not the primary focus of this analysis. However, it is certainly an important point for further research.

where $E_{t-1}\{a_t\}$ denotes an estimation error in trend output. Whenever it is greater one, trend is overestimated and vice versa. The adjustment account is then given by

$$ac_t = (1-\rho)\cdot\frac{P_{t-1}}{P_t}\cdot ac_{t-1} + \frac{\nu_t}{P_t\bar{Y}} + \left[\frac{\bar{\Psi}}{\bar{P}\bar{Y}}E_{t-1}\{a_t\} - \frac{\Psi_t}{P_t\bar{Y}}\right].$$

In log-linearized terms, this is translates into

$$\hat{G}_t = \frac{(1-\beta^{-1})}{\gamma_G}b_t + \frac{\nu_t}{\bar{P}\bar{Y}} + E_{t-1}\{\hat{a}_t\} - \rho ac_{t-1} \tag{50}$$

where we assume that $E_{t-1}\{\hat{a}_t\}$ in the following experiment and

$$ac_t = (1-\rho)ac_{t-1} + \frac{\nu_t}{\bar{P}\bar{Y}} + \gamma_G\left[E_{t-1}\{\hat{a}_t\} - \left(\hat{\Psi}_t - \hat{P}_t\right)\right]. \tag{51}$$

We see from equation (50) that overestimating trend revenues, i.e. $E_{t-1}\{\hat{a}_t\} > 0$, unambiguously increases government spending. Although this is booked on the adjustment account and partly repaid in future periods, it is straightforward to see that government spending will remain high for quite some periods, even when the estimation error is corrected immediately in the next period as the adjustment account does only partially feed back on government spending. Because trend mis-estimations are usually correlated over time due to the available time series-estimation methods, and it take quite a while to realize that $E_{t-1}\{\hat{a}_t\} > 0$ was wrong, things may even get worse. As Brunez (2003) has shown, a bias in trend estimations cannot be neglected. Kremer and Stegarescu (2008) show with German data that trend tends to be over-estimated in booms and under-estimated in downturns, while, on average, there seems to be an over-estimation. Furthermore, there may also be a positive political economic bias as suggested by Heinemann (2006).

In Figure 18, we report evidence from the following case study. We assume that the government falls prey to estimation errors for 16 quarters in a row as trend output is estimated one percentage point higher than it actually is. Each period, the government is surprised to learn that output is lower than initially expected. Nevertheless, it escribes this to some other source but trend mis-estimation.

From quarter 16 to 17, the government then realizes that trend was wrongly estimated and adjusts its expenditures accordingly. The green (high feedback, $\rho = 0.99$), black (low feedback, $\rho = 0.01$) and red (optimal baseline feedback, $\rho = 0.05$) lines report how the economy evolves under the different feedbacks. The following differences prevail.

First, the higher the feedback to the adjustment account, the lower the increase in debt. Second, from quarter 16 to 17, the economy goes into a deeper recession if fiscal expenditures are corrected sharply as, in particular, Non-Ricaridan households reduce consumption expenditures. Third, the inflation response for the optimal baseline feedback evolves smoother than the others.

We conclude that the installation of an adjustment account is able to balance the desire to keep the debt bounded, while equally not irritating the economy at large, if fiscal authorities fall prey to measurement errors.

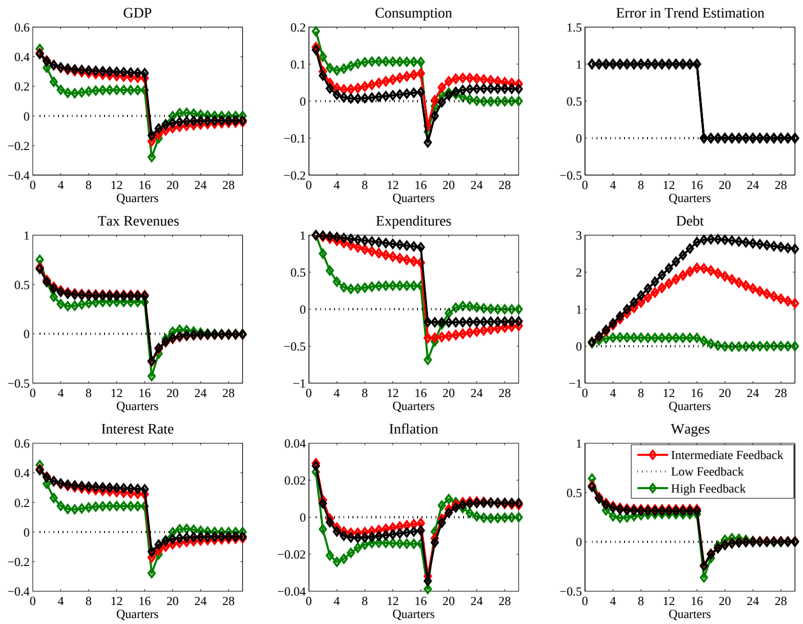

Figure 18: Trend estimation errors

5.3 Elasticities

Under current time-series estimation methods, debt brakes in action in Switzerland or proposed for Germany tie government spending to real trend revenue by estimating future revenue and correct this by a cyclical component similar to the automatic stabilizer derived in section 2.3.2 in order to boost spending in "bad times" and diminish spending in "good times" (see Colombier, 2004, 2006; Danninger, 2002; German Council of Economic Experts, 2007; for a description about the debt brake in Switzerland and the proposals in Germany). This approach may, however, result in a pro-cyclical tool which is, in terms of our model, more (but not yet fully) a balanced budget rule than an automatic stabilizer even when abstracting from estimation errors.

To make the argument clearer, let us step back to describe existing or proposed rules in terms of our model (referring also to section 2.3). Government spending, including interest on outstanding debt, according to the debt brake design just described, should be tied to projected funds raised by the government, i.e. $E_{t-1}\left\{\Psi_t\right\}$. This is augmented by projected counter-cyclical component $E_{t-1}\left\{\bar{Y}/Y_t\right\}$. Hence, ex-post government spending is given by

$$(R_{t-1}-1)B_t + P_t G_t = \underbrace{E_{t-1}\left\{\Psi_t \cdot \left(\frac{\bar{Y}}{Y_t}\right)^{\alpha}\right\} - \rho AC_{t-1}}_{=Rule\ based\ spending} + \nu_t,$$

where, as in section 2.3.2, $\alpha > 0$ is the magnitude how much revenues react in expected deviations from (estimated) trend output and the adjustment account evolves according to

$$AC_t = (1-\rho)AC_{t-1} + \nu_t + \underbrace{E_{t-1}\left\{\Psi_t \cdot \left(\frac{\bar{Y}}{Y_t}\right)^{\alpha}\right\} - \left(\Psi_t \cdot \left(\frac{\bar{Y}}{Y_t}\right)^{\alpha}\right)}_{\textit{Expectation error}}.$$

Expressing these equations in real terms (i.e. dividing by P_t), normalizing (i.e. dividing by $\bar{Y}$), assuming a zero debt economy for analytical convenience (i.e. $\bar{\bar{b}} = 0$ without loss of generality) and log-linearization (i.e. following the same procedure as presented in Appendix D), we find that

$$\hat{G}_t = \frac{(1-\beta^{-1})}{\gamma_G} b_t + \frac{\nu_t}{\bar{P}\bar{Y}} + \underbrace{E_{t-1}\left\{\hat{\Psi}_t - \hat{P}_t\right\} - \alpha \cdot E_{t-1}\left\{\hat{Y}_t\right\}}_{=\textit{Rule based spending}} - \rho ac_{t-1} \tag{52}$$

and

$$ac_t = (1-\rho)ac_{t-1} + \frac{\nu_t}{\bar{P}\bar{Y}} + \underbrace{\left[E_{t-1}\left\{\hat{\Psi}_t - \hat{P}_t\right\} - \left(\hat{\Psi}_t - \hat{P}_t\right)\right] - \alpha\left[E_{t-1}\left\{\hat{Y}_t\right\} - \hat{Y}_t\right]}_{\textit{Expectation error}}. \tag{53}$$

Taking the descriptions of the rules literally, the rules seem to imply $\alpha = 1$. However, in this case, it is a straightforward to show that, referring to equation (52), *Rule based spending* $>$ 0, which means that government spending reacts pro-cyclically to exogenous shocks. The reason for this is that the elasticity of real government revenues to any shock is larger than the elasticity of output to the same shock. This implies that, given any positive shock, government real revenues increase by more than the counter-cyclical component to dampen spending. In total, spending rises with any positive shock, while the idea of the debt brake says that it should not react (see section 2.3.2). Girouard and André (2005) have shown empirically that the elasticity relation in our model appears to hold. To solve this problem, it seems natural to set $\alpha > 1$ such that *Rule based spending* $= 0$, which corresponds with the basic idea of the rule. However, this may be quite a challenging task as it can be shown that the optimal α differs according to the shock.

6 Conclusion

In this paper, we have analyzed the effects of simple government spending rules that which aim at stabilizing the economy in a sustainable way. We used a conventional New Keynesian DSGE model to implement the idea of a balanced budget rule, a debt brake and a debt brake augmented by an additional component which moves counter-cyclical to GDP, which we termed automatic stabilizer as this is how automatic stabilizers are typically modelled in the literature. The debt brake, which is currently in action in Switzerland and proposed to be implemented in Germany, is a rule tying government spending to real trend revenues. Primary surpluses and deficits are booked on an adjustment account. The (positive) balance of the account cuts future government spending in order to keep debt at a constant level in the long run.

We find that, not surprisingly, the balanced budget rule gives pro-cyclical impulses to the economy as it directly moves with (projected) government revenues. The debt brake and the automatic stabilizer have very similar business cycle effects. However, the debt brake still acts mildly pro-cyclical which can be attributed to the interest payments on outstanding debt and to the commitment to keep overall debt stable in the long run, while the automatic stabilizer indeed acts mildly counter-cyclical. In terms of welfare, calculated as an average consumer loss function, the debt brake and the automatic stabilizer are very similar. Nevertheless, on an aggregated level, the automatic stabilizer seems to generate slightly smaller a welfare loss of 4% for our baseline calibration. This can be explained by the anticipation effect of highly correlated government expenditures, which only materialize in later periods and drive the differences in welfare results for a debt brake and an automatic stabilizer regime.

We can keep hold of the fact that, generally, attention should be devoted to the feedback of the adjustment account to real government spending. Only for discretionary spending shocks, this feedback should be relatively stronger, while adjustment of debt due to other economic shocks should die out slowly. Additionally, it is important to take into account potential estimation errors, especially, regarding trend output. Overestimating trend generates too high government spending. We conclude that the installation of an adjustment account is able to balance the desire to keep debt bounded, while not irritation the economy at large, if fiscal authorities fall prey to measurement errors.

The debt brake in action (and proposed) do not ty expenditures to expected trend revenues directly but to projected funds raised by the government in the following period augmented by a cyclical factor which is supposed to add out the cyclical fluctuations. However, in such a case, one has to carefully consider the fact that elasticities to a shock generally differ for government revenues and for output. Even without trend mis-estimation, one may generate strong pro-cyclical spending behavior if the reaction of government spending is not correctly adapted to these elasticities (which, to make things worse, differ across shocks). Then, the idea of the debt brake may be foiled and welfare implication go more in the direction of a balanced budget rule.

Appendix

A Baseline Calibration

Parameter	Symbol	Value
Discount factor	β	0.990
Elasticity of demand in intermediate good sector	ϵ	11.000
Taylor rule coefficient: inflation	ϕ_π	1.900
Taylor rule coefficient: output	ϕ_Y	0.250
Taylor rule coefficient: interest rate smoothing	μ	0.850
Feed back of adjustment account to spending	ρ	0.150
Fraction of firms that leave their price unchanged	θ_p	0.750
Fraction of firms that do price indexation	ω_p	0.000
Share of liquidity constraint consumers	λ	0.330
Steady state rate of employee wage taxes	$\bar{\tau}^d$	0.125
Steady state rate of employer wage taxes	$\bar{\tau}^w$	0.125
Steady state rate of consumption taxes	$\bar{\tau}^C$	0.183
Feedback of debt to taxes	χ_d, χ_w, χ_C	0.000
Autoregressive parameter for consumer preference shock	ρ_ζ	0.822
Autoregressive parameter for technology shock	ρ_A	0.828
Autoregressive parameter for supply shock	ρ_ϵ	0.890
Autoregressive parameter for monetary policy shock	ρ_z	0.150
Autoregressive parameter for government spending shock	ρ_ν	0.956
Autoregressive parameter for government revenue shock	ρ_χ	0.500
Relative weight of leisure to consumption	υ	0.761

Table 1: Baseline Calibrationn

Shock type	Standard deviations
Consumer preferences	0.324
Technology	0.628
Supply	0.140
Monetary policy	0.240
Government expenditure	0.331
Government revenue	0.329

Table 2: Standard Deviations of Shocks

B Optimal Firms' Price Setting and the Phillips Curve

The relevant first-order conditions of the firm's maximization problem are given by

$$\frac{\partial(.)}{\partial Q_t(j)} = \theta_p \beta \Lambda_t \left[\frac{\tilde{P}_t(j)}{P_{t+k}} - mc_{t+k}(j) - \vartheta_t^j \right] \equiv 0 \tag{54}$$

and

$$\frac{\partial(.)}{\partial \tilde{P}_t(j)} = E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} \left[\frac{Q_{t+k}(j)}{P_{t+k}} - \vartheta_{t+k} \cdot \epsilon \left(\frac{\tilde{P}_t(i)}{P_{t+k}} \right)^{-\epsilon} \frac{P_{t+k}}{\tilde{P}_{t+k}(j)} \frac{1}{P_{t+k}} Y_{t+k} \right] \right\} \equiv 0. \tag{55}$$

Using equations (4) and (54) to substitute into equation (55), we get equation (10),

$$E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} \left(\frac{\tilde{P}_t(i)}{P_{t+k}} \right)^{-\epsilon} Y_{t+k} \left[\frac{1}{P_{t+k}} - \epsilon \left(\frac{1}{P_{t+k}} - \frac{mc_{t+k}(j)}{\tilde{P}_{t+k}(j)} \right) \right] \right\} = 0.$$

$$\Rightarrow \quad (\epsilon - 1) E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} \left(\frac{\tilde{P}_t(i)}{P_{t+k}} \right)^{-\epsilon} \frac{Y_{t+k}}{P_{t+k}} \right\}$$

$$= \epsilon E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} \left(\frac{\tilde{P}_t(i)}{P_{t+k}} \right)^{-\epsilon} Y_{t+k} \frac{mc_{t+k}(j)}{\tilde{P}_{t+k}(j)} \right\}$$

$$\Rightarrow \quad \tilde{P}_t^{-\epsilon}(j)(\epsilon - 1) E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} P_{t+k}^{\epsilon-1} Y_{t+k} \right\}$$

$$= \tilde{P}_t^{-\epsilon-1}(j) \epsilon E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} P_{t+k}^{\epsilon} Y_{t+k} mc_{t+k}(j) \right\}.$$

Solving for $\tilde{P}_t(j)$ yields

$$\tilde{P}_t(j) = \frac{\epsilon}{\epsilon - 1} \cdot \frac{E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} P_{t+k}^{\epsilon} Y_{t+k} mc_{t+k}(j) \right\}}{E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} P_{t+k}^{\epsilon-1} Y_{t+k} \right\}} \tag{56}$$

as the optimal reset price for firm j that is able to reset prices. Note that if all firms were allowed to reset prices (i.e. $\theta_p = 0$), we would get

$$\tilde{P}_t(j) = \frac{\epsilon}{\epsilon - 1} \cdot E_t\{mc_t^{flex} \cdot P_t^{flex}\} = P_t^{flex}. \tag{57}$$

Equation (57) implies that, in the flexible price equilibrium, in steady-state, $\bar{mc} = \Phi = \frac{\epsilon}{\epsilon-1}$ (see also section 2.1.1), which will become handy to remember for later use.

$\tilde{P}_t(j) E_t \left\{\sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} P_{t+k}^{\epsilon-1} Y_{t+k}\right\} = \frac{\epsilon}{\epsilon-1} E_t \left\{\sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} P_{t+k}^{\epsilon} Y_{t+k} mc_{t+k}(j)\right\}$ is the rearranged equation (56), which, log-linearized, gives

$$\bar{\Lambda}\bar{P}^{\epsilon-1}\bar{Y}\bar{\tilde{P}}(j) E_t \left\{ \frac{1}{1-\beta\theta_p}\hat{\tilde{P}}_t(j) + \sum_{k=0}^{\infty} (\beta\theta_p)^k \left(\hat{\Lambda}_{t+k} + \hat{Y}_{t+k} + (\epsilon-1)\hat{P}_{t+k}\right) \right\}$$
$$= \frac{\epsilon}{\epsilon-1}\bar{\Lambda}\bar{P}^{\epsilon}\bar{Y}\bar{mc} E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \left(\hat{\Lambda}_{t+k} + \hat{Y}_{t+k} + \epsilon\hat{P}_{t+k} + \hat{mc}_{t+k}\right) \right\},$$

where we have used $\sum_{k=0}^{\infty} (\beta\theta_p)^k = \frac{1}{1-\beta\theta_p}$. Further, we know from equation (56) that $\bar{\tilde{P}} = \frac{\epsilon}{\epsilon-1}\bar{mc}\bar{P}$ which allows us to simplify the previous equations as

$$\hat{\tilde{P}}_t(j) = (1-\beta\theta_p) E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \left(\hat{P}_{t+k} + \hat{mc}_{t+k}\right) \right\},$$

which can also be written as

$$\hat{\tilde{P}}_t(j) = (1-\beta\theta_p) \left\{ \left(\hat{P}_t + \hat{mc}_t\right) + \beta\theta_p \hat{\tilde{P}}_{t+1}(j) \right\}. \tag{58}$$

The aggregated price index P_t evolves as $P_t^{(1-\epsilon)} = (1-\theta_p)(P_t^*)^{(1-\epsilon)} + \theta_p P_{t-1}^{(1-\epsilon)}$ (see Gali et al., 2001), which, in log-linearized form, yields $\hat{P}_t = (1-\theta_p)\hat{P}_t^* + \theta_p \hat{P}_{t-1}$. We further assume that the group of price setters is subdivided into optimizers, with share $(1-\omega_p)$, and those who index their prices, with share ω_p. Hence, $\hat{P}_t^* = (1-\omega_p)\hat{\tilde{P}}_t(j) + \omega_p \hat{P}_t^b$, where the indexation rule is conducted according to $\hat{P}_t^b = \hat{P}_{t-1}^* + \hat{\pi}_{t-1}$. Making use of this set of equations, it holds that

$$\hat{\tilde{P}}_t(j) = \frac{1}{1-\omega_p}\hat{P}_t^* - \frac{\omega_p}{1-\omega_p}[\hat{P}_{t-1}^* + \hat{\pi}_{t-1}]$$

and we further know that

$$\hat{P}_t^* = \frac{1}{1-\theta_p}\hat{P}_t - \frac{\theta_p}{1-\theta_p}\hat{P}_{t-1},$$

which yields (combining these two equations and rearranging)

$$\hat{\tilde{P}}_t(j) = \frac{\hat{P}_t + [\theta_p\omega_p - 2\omega_p - \theta_p]\hat{P}_{t-1} + \omega_p\hat{P}_{t-2}}{(1-\omega_p)(1-\theta_p)}.$$

Substituting the previous expression into equation (58) yields

$$\begin{aligned} \frac{\hat{P}_t + [\theta_p\omega_p - 2\omega_p - \theta_p]\hat{P}_{t-1} + \omega_p\hat{P}_{t-2}}{(1-\omega_p)(1-\theta_p)} &= (1-\beta\theta_p)\left(\hat{P}_t + \hat{mc}_t\right) \\ &\quad + \beta\theta_p \frac{\hat{P}_{t+1} + [\theta_p\omega_p - 2\omega_p - \theta_p]\hat{P}_t + \omega_p\hat{P}_{t-1}}{(1-\omega_p)(1-\theta_p)}, \end{aligned}$$

which we can rearrange to

$$\begin{aligned} & [1-(1-\omega_p)(1-\theta_p)(1-\beta\theta_p)-\beta\theta_p(\theta_p\omega_p-2\omega_P-\theta_p)]\hat{P}_t \\ = \; & \beta\theta_p\hat{P}_{t+1}+[-(\theta_p\omega_p-2\omega_P-\theta_p)+\beta\theta_p\omega_p]\hat{P}_{t-1}-\omega_p\hat{P}_{t-2} \\ & +(1-\omega_p)(1-\theta_p)(1-\beta\theta_p)\hat{mc}_t. \end{aligned}$$

Using that $\hat{\pi}_t = \hat{P}_t - \hat{P}_{t-1}$, this can be written as

$$[\theta_p+\omega_p(1-\theta_p(1-\beta))]\hat{\pi}_t = \beta\theta_p\hat{\pi}_{t+1}+\omega_p\hat{\pi}_{t-1}+(1-\omega_p)(1-\theta_p)(1-\beta\theta_p)\hat{mc}_t,$$

which yields

$$\begin{aligned} \hat{\pi}_t \;=\; & \frac{\beta\theta_p}{[\theta_p+\omega_p(1-\theta_p(1-\beta))]}\hat{\pi}_{t+1}+\frac{\omega_p}{[\theta_p+\omega_p(1-\theta_p(1-\beta))]}\hat{\pi}_{t-1} \\ & +\frac{(1-\omega_p)(1-\theta_p)(1-\beta\theta_p)}{[\theta_p+\omega_p(1-\theta_p(1-\beta))]}\hat{mc}_t, \end{aligned}$$

which is equation (37). Note that in the main text, we will set $\omega_p = 0$.

C Aggregation of Household Sector

The first-order conditions for optimizing households are

$$\frac{\partial(.)}{\partial C_t^o(j)} = \frac{(1-\chi)\zeta_t}{C_t^o(j)} - \lambda_t^o(1+\tau_t^C) = 0, \tag{59}$$

$$\frac{\partial(.)}{\partial L_t^o(j)} = \frac{\upsilon_t\zeta_t}{L_t^o(j)} - \lambda_t^o(1-\tau_t^d)w_t = 0, \tag{60}$$

and

$$\frac{\partial(.)}{\partial B_{t+1}^o(j)} = -\frac{1}{R_tP_t}\lambda_t^o + \beta E_t\left\{\lambda_{t+1}^o\frac{1}{P_{t+1}}\right\} = 0, \tag{61}$$

where λ_t^o is the Lagrangian multiplier associated with the budget constraint, equation (13). From equation (61), we know that

$$R_t^{-1} = \beta E_t\left\{\frac{\lambda_{1,t+1}^o}{\lambda_{1,t}^o}\frac{P_t}{P_{t+1}}\right\}, \tag{62}$$

which is the stochastic discount factor. Using equation (59) yields equations (14) and (15).

The first-order conditions for rule-of-thumb consumers are given by

$$\frac{\partial(.)}{\partial C_t^r(j)} = \frac{(1-\chi)\zeta_t}{C_t^r(j)} - \lambda_t^r(1+\tau_t^C) = 0 \tag{63}$$

and

$$\frac{\partial(.)}{\partial L_t^r(j)} = \frac{\upsilon_t \zeta_t}{L_t^r(j)} - \lambda_t^r (1-\tau_t^d) w_t = 0, \tag{64}$$

where λ_t^r is the Lagrangian multiplier associated with the corresponding budget constraint. From equations (63) and (64), we derive equation (18).

The aim of the rest of this section is to derive an aggregated consumption Euler equation (in log-linearized terms) expressed only in aggregated variables and deep parameters. To achieve this, we revert to the households' consumption decisions derived in subsections 2.2.1 and 2.2.2. This means that we have to back-step every now and then to simplify the resulting equations. The principle of aggregation follows what we have stated in equation (1).

Using the principle of equation (1), we know with the help of equation (19) that

$$N_t = \lambda N_t^r + (1-\lambda) N_t^o = \frac{\lambda \cdot (1-\chi)}{(1-\chi)+\upsilon_t} + (1-\lambda) N_t^o \tag{65}$$

and that

$$\begin{aligned} C_t &= \lambda C_t^r + (1-\lambda) C_t^o \\ &= \lambda \left[\frac{(1-\chi)}{\upsilon_t} w_t \frac{(1-\tau_t^d)}{(1+\tau_t^C)} L_t^r \right] + (1-\lambda) \left[\frac{(1-\chi)}{\upsilon_t} w_t \frac{(1-\tau_t^d)}{(1+\tau_t^C)} L_t^o \right] \\ &= \left[\frac{(1-\chi)}{\upsilon_t} w_t \frac{(1-\tau_t^d)}{(1+\tau_t^C)} \right] \underbrace{[\lambda L_t^r + (1-\lambda) L_t^o]}_{\equiv L_t}, \end{aligned} \tag{66}$$

where the index j has been dropped for notational convenience[6], while C_t^r is given by equation (18) and C_t^o by equation (15). Log-linearization of equation (66) yields

$$\hat{C}_t - \hat{L}_t = \hat{w}_t - \iota^d \hat{\tau}_t^d - \iota^C \hat{\tau}_t^C - \hat{\upsilon}_t,$$

where $\iota^d \equiv \frac{\bar{\tau}^d}{(1-\bar{\tau}^d)}$ and $\iota^C \equiv \frac{\bar{\tau}^C}{(1+\bar{\tau}^C)}$. We know that $\hat{L}_t = -\frac{\bar{N}}{1-\bar{N}} \hat{N}_t = -\varphi \hat{N}_t$ from log-linearizing $L_t = 1 - N_t$, where $\varphi = \frac{\bar{N}}{1-\bar{N}}$ is the inverse of the Fisher labor supply elasticity. Substituting $\hat{L}_t$ and rearranging thus gives

$$\hat{w}_t = \hat{C}_t + \varphi \hat{N}_t + \iota^d \hat{\tau}_t^d + \iota^C \hat{\tau}_t^C + \hat{\upsilon}_t, \tag{67}$$

which is equation (39) of the main text.

We now come to some side-steps to derive be able to derive the aggregated Consumption-Euler equation. From equation (20) we know that, in steady-state, $\bar{C}^r = \frac{(1-\bar{\tau}^d)(1-\chi)}{((1-\chi)+\upsilon)(1+\bar{\tau}^C)} \bar{w}$,

[6] Note that, due to state-contingent claims available for optimizing households, which is generally assumed in this type of model, and the fact that rule-of-thumb consumers consume all of their income, each individual household's consumption in $i = o, r$ is equal anyway (see Woodford, 2003, chapter 2).

while, from equation (66) and $\bar{L} = 1 - \bar{N}$, it is clear that $\bar{C} = (1-\bar{N})\frac{(1-\bar{\tau}^d)(1-\chi)}{\upsilon(1+\bar{\tau}^C)}\bar{w}$, which yields

$$\frac{\bar{C}^r}{\bar{C}} = \frac{\upsilon}{1-\chi+\upsilon} \cdot \frac{1}{1-\bar{N}} \equiv \gamma_r, \tag{68}$$

where γ_r is, thus, the per-head consumption share of rule-of-thumb households relative to total per-head consumption. As we further know from equation (66) that $\bar{C} = \lambda\bar{C}^r + (1-\lambda)\bar{C}^o$, we find that $1 = \lambda\frac{\bar{C}^r}{\bar{C}} + (1-\lambda)\frac{\bar{C}^o}{\bar{C}}$, which, using equation (68) can be reformulated as

$$\frac{\bar{C}^o}{\bar{C}} = \frac{1}{1-\lambda} - \frac{\lambda}{1-\lambda}\underbrace{\frac{\upsilon}{1-\chi+\upsilon}\frac{1}{1-\bar{N}}}_{=\gamma_r} = \frac{1-\gamma_r\lambda}{1-\lambda} \equiv \gamma_o, \tag{69}$$

which, equivalently, gives the per-head consumption share of optimizing households relative to total per-head consumption. (Note that, whenever optimizing households consume more than rule-of-thumb households, $\gamma_o > 1$ may well be possible and vice versa). Using $\bar{L} = \lambda\bar{L}^r + (1-\lambda)\bar{L}^o = \lambda(1-\bar{N}^r) + (1-\lambda)\bar{L}^o$, where $\bar{N}^r$ is given by equation (19), we know that $\bar{L} = \lambda\left(1 - \frac{(1-\chi)}{1-\chi+\upsilon}\right) + (1-\lambda)\bar{L}^o$, which, dividing both sides by $\bar{L} = (1-\bar{N})$ yields $1 = \gamma_r\lambda + (1-\lambda)\frac{\bar{L}^o}{\bar{L}}$, where γ_r is given by equation (68). Thus,

$$\frac{\bar{L}^o}{\bar{L}} = \frac{1-\gamma_r\lambda}{1-\lambda} = \gamma_o \tag{70}$$

is also the per-head leisure of optimizing households relative to total per-head leisure.

From equation (14), we know that, for the optimizing households, it holds that

$$\frac{\zeta_t}{C_t^o \cdot (1+\tau_t^C)} = \beta R_t E_t\left\{\frac{\zeta_{t+1}}{C_{t+1}^o \cdot (1+\tau_{t+1}^C)} \cdot \frac{P_t}{P_{t+1}}\right\}. \tag{71}$$

A Taylor expansion and use of $E_t r_t = E_t\left\{R_t \cdot \frac{P_t}{P_{t+1}}\right\}$ yields

$$\begin{aligned}
&\frac{\bar{\zeta}}{\bar{C}^o \cdot (1+\bar{\tau}^C)}\left[-\frac{(C_t^o - \bar{C}^o)}{\bar{C}}\frac{\bar{C}}{\bar{C}^o} + \frac{(\zeta_t - \bar{\zeta})}{\bar{\zeta}} - \frac{\bar{\tau}^C}{1+\bar{\tau}^C}\frac{(\tau_t^C - \bar{\tau}^C)}{\bar{\tau}^w}\right] \\
&= \beta\bar{r}\frac{\bar{\zeta}}{\bar{C}^o \cdot (1+\bar{\tau}^C)}E_t\left[-\frac{(C_{t+1}^o - \bar{C}^o)}{\bar{C}}\frac{\bar{C}}{\bar{C}^o} + \frac{(\zeta_{t+1} - \bar{\zeta})}{\bar{\zeta}} - \frac{\bar{\tau}^C}{1+\bar{\tau}^C}\frac{(\tau_{t+1}^C - \bar{\tau}^C)}{\bar{\tau}^w} + \frac{1}{\bar{r}}(r_t - \bar{r})\right].
\end{aligned}$$

We now define $\hat{C}_t^o \equiv \frac{(C_t^o - \bar{C}^o)}{\bar{C}}$ and $\hat{L}_t^o \equiv \frac{(L_t^o - \bar{L}^o)}{\bar{L}}$ and note that $\frac{\bar{C}}{\bar{C}^o} = \frac{\bar{L}}{\bar{L}^o} = \frac{1}{\gamma_o}$ (see equations (69) and (70))[7] as well as $\bar{r} = \beta^{-1}$. Substitution and rearranging yields

$$\left[-\hat{C}_t^o\frac{1}{\gamma_o} + \hat{\zeta}_t - \iota^C\hat{\tau}_t^C\right] = E_t\left[-\hat{C}_{t+1}^o\frac{1}{\gamma_o} + \hat{\zeta}_{t+1} - \iota^C\hat{\tau}_{t+1}^C + \hat{r}_t\right],$$

[7] Note that this is, then, the deviation of C_t^o or L_t^o from its steady-state value evaluated at the steady-state value of total consumption/leisure. This is corrected for by dividing this term by γ_o in the following equation. The slightly different definition from the standard definition will be useful for further calculations.

where $\iota^C = \frac{\bar{\tau}^C}{1+\bar{\tau}^C}$. Rearranging gives

$$\hat{C}_t^o = E_t\hat{C}_{t+1}^o + \gamma_o \left\{ \iota^C E_t[\hat{\tau}_{t+1}^C - \hat{\tau}_t^C] + E_t[\hat{\zeta}_t - \hat{\zeta}_{t+1}] - \hat{r}_t \right\}. \tag{72}$$

We define $\Delta\hat{L}_{t+1}^o = [\hat{L}_{t+1}^o - \hat{L}_t^o]$ and $\Delta\hat{\tau}_{t+1}^C = [\hat{\tau}_{t+1}^C - \hat{\tau}_t^C]$ for later use.

From equation (65), we know that $\frac{N_t}{\bar{N}} = \frac{\lambda\cdot(1-\chi)}{\bar{N}((1-\chi)+\upsilon_t)} + (1-\lambda)\frac{N_t^o}{\bar{N}}$. A first-order Taylor expansion implies that

$$\hat{N}_t^o = \frac{\hat{N}_t}{1-\lambda} + \frac{\lambda}{(1-\lambda)\bar{N}}\frac{(1-\chi)\upsilon}{(1-\chi+\upsilon)^2}\hat{\upsilon}_t \;\Rightarrow\; \hat{L}_t^o = -\frac{\varphi}{1-\lambda}\hat{N}_t - \frac{\lambda\varphi}{(1-\lambda)\bar{N}}\frac{(1-\chi)\upsilon}{(1-\chi+\upsilon)^2}\hat{\upsilon}_t \tag{73}$$

because $\hat{L}_t = -\frac{\bar{N}}{1-\bar{N}}\hat{N}_t = -\varphi\hat{N}_t$, where we have defined $\hat{N}_t^o = \frac{N_t^o - \bar{N}^o}{\bar{N}}$. From equation (20) and (66), it must hold that $\frac{C_t^r}{\bar{C}} = \frac{C_t}{\bar{C}}\frac{\upsilon_t}{(1-\chi)+\upsilon_t}\frac{1}{1-N_t}$, where a first-order Taylor expansion yields

$$\hat{C}_t^r = \gamma_r\hat{C}_t + \varphi\gamma_r\hat{N}_t + \gamma_r\frac{(1-\chi)}{1-\chi+\upsilon}\hat{\upsilon}_t, \tag{74}$$

where we have used the definition for γ_r (see equation (68)), $\varphi = \bar{N}/(1-\bar{N})$ and defined $\hat{C}_t^r = \frac{C_t^r - \bar{C}^r}{\bar{C}}$. Log-linearizing aggregated consumption $C_t = \lambda C_t^r + (1-\lambda)C_t^o$ yields $\hat{C}_t = \lambda\hat{C}_t^r + (1-\lambda)\hat{C}_t^o$. Solving this for $\hat{C}_t^o$ and using equation (74) yields

$$\hat{C}_t^o = \underbrace{\frac{1-\gamma_r\lambda}{1-\lambda}}_{=\gamma_o}\hat{C}_t - \frac{\lambda\gamma_r\varphi}{1-\lambda}\hat{N}_t - \frac{\gamma_r\lambda(1-\chi)}{(1-\chi+\upsilon)(1-\lambda)}\hat{\upsilon}_t. \tag{75}$$

From equation (73), we know that $\Delta\hat{L}_{t+1}^o = -\frac{\varphi}{(1-\lambda)}\Delta\hat{N}_{t+1}$ must hold. Substituting this and equation (75) into equation (72) we get

$$\begin{aligned}\gamma_o\hat{C}_t \quad - \quad & \frac{\lambda\gamma_r\varphi}{(1-\lambda)}\hat{N}_t - \frac{\gamma_r\lambda(1-\chi)}{(1-\chi+\upsilon)(1-\lambda)}\hat{\upsilon}_t - \gamma_o\hat{\zeta}_t = \gamma_o E_t\hat{C}_{t+1} - \frac{\lambda\gamma_r\varphi}{(1-\lambda)}E_t\hat{N}_{t+1} \\ & -\frac{\gamma_r\lambda(1-\chi)}{(1-\chi+\upsilon)(1-\lambda)}E_t[\hat{\upsilon}_{t+1}] + \gamma_o\left\{\iota^C E_t\Delta\hat{\tau}_{t+1}^C - E_t[\hat{\zeta}_{t+1}] - E_t[\hat{R}_t - \hat{\pi}_{t+1}]\right\},\end{aligned}$$

where we have used that $\hat{r}_t = [\hat{R}_t - \hat{\pi}_{t+1}]$, with $\hat{\pi}_{t+1} \approx \hat{P}_{t+1} - \hat{P}_t$. Dividing by γ_o, i.e. multiplying by $\frac{(1-\lambda)}{1-\gamma_r\lambda}$, we get equation (72). Equation (38) is the standard aggregated consumption Euler equation expressed in aggregated variables and deep parameters only. Individual steady-state relations have been substituted out but, of course, still drive equation (38) through the "correct" substitution.

D The Fiscal Spending Rule

Before deriving the spending rule in log-linearized terms, it seems appropriate to have some steady-state considerations regarding the spending rule, equations (28) and (30), and the adjustment account, equations (29) and (31). From these equations, we see that, in steady-state,

$$(\bar{R}-1)\bar{\tilde{b}}+\frac{\bar{G}}{\bar{Y}}=\frac{\bar{\Psi}}{\bar{P}\bar{Y}}-\rho\cdot\bar{ac} \tag{76}$$

and

$$\bar{ac}=(1-\rho)\bar{ac}+\frac{\bar{\Psi}}{\bar{P}\bar{Y}}-\frac{\bar{\Psi}}{\bar{P}\bar{Y}} \;\Rightarrow\; \rho\cdot\bar{ac}=0. \tag{77}$$

As we know that $\rho>0$ if the adjustment account feeds back on government spending, $\bar{ac}=0$ has to hold in steady-state. Then, from equation (76), we know that $\frac{\bar{\Psi}}{\bar{P}\bar{Y}}=\gamma_G-(1-\beta^{-1})\bar{\tilde{b}}$, where we have used the definition $\gamma_G=\frac{\bar{G}}{\bar{Y}}$ and the fact that $\bar{R}=\beta^{-1}$ in steady-state. Note that these conditions correspond to the evolution of debt in steady-state, given by equation (24) in steady-state, which also gives $\frac{\bar{\Psi}}{\bar{P}\bar{Y}}=\gamma_G-(1-\beta^{-1})\bar{\tilde{b}}$, but where the adjustment account has not yet been taken into account. Hence, the fact that $\bar{ac}=0$ in steady-state is consistent with the model.

A first-order Taylor expansion of equation (24) yields

$$\begin{aligned}
&\underbrace{\left[\bar{\tilde{b}}+\frac{\bar{\Psi}}{\bar{P}\bar{Y}}\right]}_{=\gamma_G+\beta^{-1}\bar{\tilde{b}}}+\underbrace{\left(\tilde{b}_{t+1}-\bar{b}\right)}_{=b_{t+1}}+\frac{1}{\bar{P}\bar{Y}}\left(\Psi_t-\bar{\Psi}\right)-\frac{\bar{\Psi}}{\bar{P}^2\bar{Y}}\left(P_t-\bar{P}\right)\\
&=\underbrace{\left[\bar{R}\bar{\tilde{b}}+\frac{\bar{G}}{\bar{Y}}\right]}_{=\gamma_G+\beta^{-1}\bar{\tilde{b}}}+\bar{\tilde{b}}\left(R_{t-1}-\bar{R}\right)+\bar{R}\underbrace{\left(\tilde{b}_t-\bar{b}\right)}_{=b_t}+\frac{\bar{R}\bar{\tilde{b}}}{\bar{P}}\left(P_{t-1}-\bar{P}\right)\\
&-\frac{\bar{R}\bar{\tilde{b}}\bar{P}}{\bar{P}^2}\left(P_t-\bar{P}\right)+\frac{1}{\bar{Y}}\left(G_t-\bar{G}\right),
\end{aligned}$$

where use has been made of equations (25) and (76) to derive the terms in the underbraces. Using the definition for any variable's deviation around its steady-state, equation (2), as well as equation (76) and $\bar{R}=\beta^{-1}$, we can rearrange the above equation to $b_{t+1}+\left[\gamma_G-\bar{\tilde{b}}(1-\beta^{-1})\right]\left(\hat{\Psi}_t-\hat{P}_t\right)=\beta^{-1}b_t+\beta^{-1}\bar{\tilde{b}}\left(\hat{R}_{t-1}+\hat{P}_{t-1}-\hat{P}_t\right)+\gamma_G\hat{G}_t$.[8] Using the definition $\hat{\pi}_t\approx\hat{P}_t-\hat{P}_{t-1}$, rearranging yields equation (40).

[8]Remember that $\bar{\Psi}/(\bar{P}\bar{Y})=\gamma_G-\bar{\tilde{b}}(1-\beta^{-1})$.

A first-order Taylor expansion of the spending rule, equation (30), yields

$$\begin{aligned}
&\underbrace{\left[(\bar{R}-1)\bar{b}+\frac{\bar{G}}{\bar{Y}}\right]}_{=\gamma_G-(1-\beta^{-1})\bar{\bar{b}}}+(\bar{R}-1)\underbrace{(\tilde{b}_t-\bar{b})}_{=b_t}+\bar{\bar{b}}\left(R_{t-1}-\bar{R}\right)+\frac{(\bar{R}-1)\bar{\bar{b}}}{\bar{P}}\left(P_{t-1}-\bar{P}\right)\\
&-\frac{(\bar{R}-1)\bar{\bar{b}}\bar{P}}{\bar{P}^2}\left(P_t-\bar{P}\right)+\frac{1}{\bar{Y}}\left(G_t-\bar{G}\right)\\
&=\underbrace{\left[\frac{\bar{\Psi}}{\bar{P}\bar{Y}}\right]}_{=\gamma_G-(1-\beta^{-1})\bar{\bar{b}}}-\underbrace{\left[\frac{\bar{\Psi}}{\bar{P}\bar{Y}}\right]}_{=\gamma_G-(1-\beta^{-1})\bar{\bar{b}}}\cdot\alpha\cdot E_{t-1}\left\{\hat{Y}_t\right\}+\frac{\nu_t}{\bar{P}\bar{Y}}-\rho\cdot ac_{t-1},
\end{aligned}$$

whereas a first-order Taylor expansion of equation (28) yields

$$\begin{aligned}
&\underbrace{\left[(\bar{R}-1)\bar{b}+\frac{\bar{G}}{\bar{Y}}\right]}_{=\gamma_G-(1-\beta^{-1})\bar{\bar{b}}}+(\bar{R}-1)\underbrace{(\tilde{b}_t-\bar{b})}_{=b_t}+\bar{\bar{b}}\left(R_{t-1}-\bar{R}\right)+\frac{(\bar{R}-1)\bar{\bar{b}}}{\bar{P}}\left(P_{t-1}-\bar{P}\right)\\
&-\frac{(\bar{R}-1)\bar{\bar{b}}\bar{P}}{\bar{P}^2}\left(P_t-\bar{P}\right)+\frac{1}{\bar{Y}}\left(G_t-\bar{G}\right)\\
&=\underbrace{\left[\frac{\bar{\Psi}}{\bar{P}\bar{Y}}\right]}_{=\gamma_G-(1-\beta^{-1})\bar{\bar{b}}}+\underbrace{\left[\frac{\bar{\Psi}}{\bar{P}\bar{Y}}\right]}_{=\gamma_G-(1-\beta^{-1})\bar{\bar{b}}}\cdot E_{t-1}\left\{\hat{\Psi}_t-\hat{P}_t\right\}+\frac{\nu_t}{\bar{P}\bar{Y}}-\rho\cdot ac_{t-1}.
\end{aligned}$$

where we have already used the fact that $\bar{ac}=\bar{\nu}=0$ and we used the definition of equation (25) and and the steady-state condition (76). Solving for $\hat{G}_t$, and combining the two previous equations yields equation (42).

A first-order Taylor expansion of equation (31) yields

$$\begin{aligned}
(ac_t-\bar{ac}) &= (1-\rho)(ac_{t-1}-\bar{ac})+\underbrace{\frac{\bar{ac}}{\bar{P}}(P_{t-1}-\bar{P})-\frac{\bar{ac}}{\bar{P}^2}(P_t-\bar{P})}_{=0}+\frac{\nu_t}{\bar{P}\bar{Y}}\\
&\quad-\underbrace{\frac{\bar{\Psi}}{\bar{P}\bar{Y}}}_{=\gamma_G-(1-\beta^{-1})\bar{\bar{b}}}\cdot\left[\alpha\left(E_{t-1}\left\{\hat{Y}_t\right\}-\hat{Y}_t\right)+\varrho\left(\hat{\Psi}_t-\hat{P}_t\right)\right],
\end{aligned}$$

while a fist-order Taylor expansion of equation (29) is given by

$$\begin{aligned}
(ac_t-\bar{ac}) &= (1-\rho)(ac_{t-1}-\bar{ac})+\underbrace{\frac{\bar{ac}}{\bar{P}}(P_{t-1}-\bar{P})-\frac{\bar{ac}}{\bar{P}^2}(P_t-\bar{P})}_{=0}+\frac{\nu_t}{\bar{P}\bar{Y}}\\
&\quad+\underbrace{\frac{\bar{\Psi}}{\bar{P}\bar{Y}}}_{=\gamma_G-(1-\beta^{-1})\bar{\bar{b}}}\cdot\left[\left(E_{t-1}\left\{\hat{\Psi}_t\right\}-\hat{\Psi}_t\right)-\left(E_{t-1}\left\{\hat{P}_t\right\}-\hat{P}_t\right)\right],
\end{aligned}$$

which can be combined to equation (43).

E Steady-state considerations

We know that, in the long-run, equilibrium prices will be equal to the flex-price equilibrium. Then, we know that it holds that (see also equation (57))

$$\bar{mc} = \frac{\epsilon - 1}{\epsilon}, \tag{78}$$

where we have used that $\tilde{P}_t(i) = P_t^{flex}$ holds in the long-run steady-state. Additionally, we know from the cost minimization problem of a representative firm that (see equation (7))

$$\bar{w} = \cdot \bar{mc} \frac{\bar{Y}}{\bar{N}} \frac{1}{(1 + \bar{\tau}^w)}. \tag{79}$$

From equation (66), we know that $\bar{w} = \frac{\upsilon}{(1-\chi)} \frac{\bar{C}}{1-\bar{N}} \frac{(1+\bar{\tau}^C)}{(1-\bar{\tau}^d)}$, which, in combination with equation (79) yields

$$\begin{aligned}
&\frac{\upsilon}{(1-\chi)} \frac{\bar{C}}{1-\bar{N}} \frac{(1+\bar{\tau}^C)}{(1-\bar{\tau}^d)} = \bar{mc} \cdot \frac{\bar{Y}}{\bar{N}} \frac{1}{(1+\bar{\tau}^w)} \\
&\Rightarrow \frac{\bar{N}}{1-\bar{N}} = \bar{mc} \frac{(1-\bar{\tau}^d)}{(1+\bar{\tau}^w)(1+\bar{\tau}^C)} \frac{\upsilon}{(1-\chi)} \frac{\bar{Y}}{\bar{C}} \\
&\Rightarrow \frac{\bar{N}}{1-\bar{N}} = \underbrace{\frac{\epsilon-1}{\epsilon} \frac{(1-\bar{\tau}^d)}{(1+\bar{\tau}^w)(1+\bar{\tau}^C)} \frac{\upsilon}{(1-\chi)} \frac{1}{\gamma_C}}_{=\varphi},
\end{aligned} \tag{80}$$

where we have used equation (78) and defined $\gamma_C = \frac{\bar{C}}{\bar{Y}}$. Hence, we know that $\bar{N} = \frac{\varphi}{1+\varphi}$. This implies that $\bar{N}$ can be expressed in exogenous parameters if we are able to find a solution for γ_C which we will derive now.

Note that, from steady-state condition resulting from equation (76), we know that $\frac{\bar{\Psi}}{\bar{P}\bar{Y}} = \gamma_G - (1-\beta^{-1})\bar{\bar{b}}$ holds, where $\bar{\bar{b}} = 0$ in the zero steady-state debt case. Further, it holds that (see equation (23))

$$\frac{\bar{\Psi}}{\bar{P}\bar{Y}} = \bar{\tau}^L \bar{w} \frac{\bar{N}}{\bar{Y}} + \bar{\tau}^C \frac{\bar{C}}{\bar{Y}},$$

where $\bar{\tau}^L = \bar{\tau}^w + \bar{\tau}^d$. Using equations (78) and (79), the definition $\gamma_C = \frac{\bar{C}}{\bar{Y}}$ and combining the last two equations yields

$$\gamma_G - (1-\beta^{-1})\bar{\bar{b}} = \bar{\tau}^L \frac{\epsilon - 1}{\epsilon} \frac{1}{(1+\bar{\tau}^w)} + \bar{\tau}^C \gamma_C. \tag{81}$$

From the resource constraint, $\bar{Y} = \bar{C} + \bar{G}$, we know that $1 = \frac{\bar{C}}{\bar{Y}} + \frac{\bar{G}}{\bar{Y}} = \gamma_C + \gamma_G$. Using this and equation (81), we then find that

$$\frac{\bar{G}}{\bar{Y}} = \gamma_G = \frac{1}{(1+\bar{\tau}^C)} \left\{ (1-\beta^{-1})\bar{\tilde{b}} + \frac{\epsilon - 1}{\epsilon} \bar{\tau}^L \frac{1}{(1+\bar{\tau}^w)} + \bar{\tau}^C \right\} \tag{82}$$

is determined by exogenous parameters. Hence, from the resource constraint, we know that, then

$$\frac{\bar{C}}{\bar{Y}} \equiv \gamma_C = 1 - \gamma_G. \tag{83}$$

From the first-order condition of the cost minimizing problem of the firm, we know that $\bar{mc} = \frac{\bar{N}}{\bar{Y}} [(1+\bar{\tau}^w)\bar{w}]$ (see equation (7)), where $\frac{\bar{N}}{\bar{Y}} = \frac{1}{\bar{A}} = 1$ as $\bar{A} = 1$ (see equation (6)), which, using equation (78) and rearranging yields

$$\bar{w} = \frac{1}{(1+\bar{\tau}^w)} \frac{\epsilon - 1}{\epsilon}. \tag{84}$$

From equation (66) we can then calculate

$$\bar{C} = \frac{(1-\chi)}{\upsilon} \cdot \frac{1-\bar{\tau}^d}{1+\bar{\tau}^C} (1-\bar{N})\bar{w} = \frac{(1-\chi)}{\upsilon} \cdot \frac{(1-\bar{\tau}^d)(1-\bar{N})}{(1+\bar{\tau}^C)(1+\bar{\tau}^w)} \frac{\epsilon-1}{\epsilon}, \tag{85}$$

where $\bar{w}$ is given by equation (84) and $\bar{N}$ by equation (80). Using equation (85) and $\gamma_C = \frac{\bar{C}}{\bar{Y}}$, where γ_C is given by equation (83), we can calculate

$$\bar{Y} = \frac{\bar{C}}{\gamma_C}. \tag{86}$$

An analogous proceeding allows us – using equations (82) and (86) – to derive

$$\bar{G} = \gamma_G \bar{Y} = \bar{C} \frac{\gamma_G}{\gamma_C}. \tag{87}$$

Further, we know, using equation (81), that

$$1 = \underbrace{\frac{\bar{\tau}^L(\epsilon - 1)}{\epsilon(1+\bar{\tau}^w)[\gamma_G - (1-\beta^{-1})\bar{\tilde{b}}]}}_{=Rev^L} + \underbrace{\frac{\bar{\tau}^C}{\gamma_C[\gamma_G - (1-\beta^{-1})\bar{\tilde{b}}]}}_{=Rev^{Vat}}, \tag{88}$$

where all parameters are know following the calculation above. This implies that we are able to express all aggregated variables in terms of exogenous parameters. Note that these aggregated variables in steady-state are independent of the implemented government spending policy regime, i.e. they are independent of whether automatic stabilizers, the debt brake or no restriction on government spending apply. Note further that $\chi = \gamma_G$ following from an "optimal planner's solution" (see Gali and Monacelli, 2008; who apply exactly the same calculation procedure that is necessary here).

F Welfare Approximation

We know that per-period utility of household j of type i is given by

$$\left\{ \underbrace{\zeta_t \left[(1-\chi)log\left(C_t^i(j)\right) + \chi log(G_t)\right]}_{=u^i} + \underbrace{\zeta_t \upsilon_t log\left(L_t^i(j)\right)}_{=V^i} \right\}, \tag{89}$$

where $i = o, r$ (see also equations (12) and (16)). In what follows, we will derive the second-order Taylor approximation of the consumption part of this equation (indicated by u^i) and the leisure part (indicated by V^i) separately for convenience. For consumption, we then get

$$\begin{aligned}
u_t^i &\approx \bar{u}^i + \bar{u}_{C^i}^i\left(C_t^i - \bar{C}^i\right) + \frac{1}{2}\bar{u}_{C^iC^i}^i\left(C_t^i - \bar{C}^i\right)^2 + \bar{u}_G^i\left(G_t - \bar{G}\right) + \frac{1}{2}\bar{u}_{GG}^i\left(G_t - \bar{G}\right)^2 \\
&\quad + \bar{u}_{C^i\zeta}^i\left(C_t^i - \bar{C}^i\right)\left(\zeta_t - \bar{\zeta}\right) + \bar{u}_{G\zeta}^i\left(G_t - \bar{G}\right)\left(\zeta_t - \bar{\zeta}\right) \\
&= \bar{u}^i + (1-\chi)\frac{\left(C_t^i - \bar{C}^i\right)}{\bar{C}^i} - (1-\chi)\frac{1}{2}\frac{\left(C_t^i - \bar{C}^i\right)^2}{(\bar{C}^i)^2} + \chi\frac{\left(G_t - \bar{G}\right)}{\bar{G}} - \chi\frac{1}{2}\frac{\left(G_t - \bar{G}\right)^2}{\bar{G}^2} \\
&\quad + \frac{\left(\zeta_t - \bar{\zeta}\right)}{\bar{\zeta}}\left[(1+\chi)\frac{\left(C_t^i - \bar{C}^i\right)}{\bar{C}^i} + \chi\frac{\left(G_t - \bar{G}\right)}{\bar{G}}\right] \\
&= \bar{u}^i + (1+\hat{\zeta}_t)\left\{(1-\chi)\left[\frac{\hat{C}_t^i}{\gamma_i} - \frac{1}{2}\frac{(\hat{C}_t^i)^2}{\gamma_i^2} + \frac{1}{2}\frac{(\hat{C}_t^i)^2}{\gamma_i^2}\right] + \chi\left[\hat{G}_t - \frac{1}{2}(\hat{G}_t)^2 + \frac{1}{2}(\hat{G}_t)^2\right]\right\} \\
&= \bar{u}^i + (1+\hat{\zeta}_t)\left\{(1-\chi)\frac{\hat{C}_t^i}{\gamma_i} + \chi\hat{G}_t\right\},
\end{aligned} \tag{90}$$

where we have used the fact that we defined $\hat{C}_t^i = \frac{(C_t^i - \bar{C}^i)}{\bar{C}}$ earlier, used the definitions for γ_r and γ_o (see equations (68) and (69), respectively) and made use of the commonly known fact that, for any variable X, it holds that $(X_t - \bar{X}) \approx \bar{X}[\hat{X}_t + \frac{1}{2}\hat{X}_t^2]$ and $(X_t - \bar{X})^2 \approx \frac{1}{2}\hat{X}_t^2$ when approximating second order. Further, we have neglected the individual household parameter j for notational convenience and remembered that $\bar{\zeta} = 1$. Remembering that $E_t\{\upsilon_t\} = \bar{\upsilon} = \upsilon$, we get in an analogous proceeding for the disutility of labor (utility of leisure, respectively)

$$\begin{aligned} V_t^i &\approx \bar{V}^i + \bar{V}^i_{L^i}\left(L_t^i - \bar{L}^i\right) + \frac{1}{2}\bar{V}^i_{L^iL^i}\left(L_t^i - \bar{L}^i\right)^2 + \bar{V}^i_{L^i\zeta}\left(L_t^i - \bar{L}^i\right)\left(\zeta_t - \bar{\zeta}\right) \\ &\quad + \bar{V}^i_{L^i\upsilon}\left(L_t^i - \bar{L}^i\right)\left(\upsilon_t - \bar{\upsilon}\right) \\ &= \bar{V}^i + \upsilon\frac{\left(L_t^i - \bar{L}^i\right)}{\bar{L}^i} - \upsilon\frac{1}{2}\frac{\left(L_t^i - \bar{L}^i\right)^2}{(\bar{L}^i)^2} + \upsilon\frac{\left(L_t^i - \bar{L}^i\right)\left(\zeta_t - 1\right)}{\bar{L}^i} \\ &\quad + \frac{\left(L_t^i - \bar{L}^i\right)\left(\upsilon_t - \upsilon\right)}{\bar{L}^i} \\ &= \bar{V}^i + \upsilon\left\{\left[\frac{\hat{L}_t^i}{\gamma_i} - \frac{1}{2}\frac{(\hat{L}_t^i)^2}{\gamma_i^2} + \frac{1}{2}\frac{(\hat{L}_t^i)^2}{\gamma_i}\right]\right\} + \frac{\hat{L}_t^i}{\gamma_i}\left(\upsilon\hat{\zeta}_t + \hat{\upsilon}_t\right) \\ &= \bar{V}^i + (1+\hat{\zeta}_t)\upsilon\frac{\hat{L}_t^i}{\gamma_i} + \hat{\upsilon}_t\frac{\hat{L}_t^i}{\gamma_i} = \bar{V}^i + \Big((1+\hat{\zeta}_t)\upsilon + \hat{\upsilon}_t\Big)\frac{\hat{L}_t^i}{\gamma_i}. \end{aligned} \tag{91}$$

Combining the utility of consumption and disutility of labor, we get for household j of type $i = o, r$ that

$$U_t^i(j) = \underbrace{\bar{u}^i(j) + \bar{V}^i(j)}_{\bar{U}^i} + (1+\hat{\zeta}_t)\left\{(1-\chi)\frac{\hat{C}_t^i(j)}{\gamma_i} + \chi\hat{G}_t\right\} + \Big((1+\hat{\zeta}_t)\upsilon + \hat{\upsilon}_t\Big)\frac{\hat{L}_t^i(j)}{\gamma_i}. \tag{92}$$

Noting that individuals of type r have a constant (potentially disturbed by common preference shocks, but always equal within the group) consumption pattern due to constant (potentially disturbed by common preference shocks, but always equal within the group) labor supply (see equations (19) and (20)), we know that $\hat{C}_t^r(j) = \hat{C}_t^r$, where the latter is given by equation (74). Due to the assumption of complete markets and state-contingent claims that can be purchased by households of type o, we know that $\hat{C}_t^o(j) = \hat{C}_t^o$ (see Woodford, 2003, chapter 2 for more details), where the latter is given by equation (75). Unfortunately, this does not hold for the labor supply (i.e. leisure) except for households of type r. We will come back to this in a second. As we further know that a share λ of households is of type r, while the remaining ones, i.e. $(1-\lambda)$, are of type o, aggregated per-period utility can be expressed through the second-order Taylor approximation

$$\begin{aligned} U_t &= \lambda\bar{U}^r + (1-\lambda)\bar{U}^o + (1+\hat{\zeta}_t)\left\{(1-\chi)\left[\lambda\frac{\hat{C}_t^r}{\gamma_r} + (1-\lambda)\frac{\hat{C}_t^o}{\gamma_o}\right] + \chi\hat{G}_t\right\} \\ &\quad + \Big((1+\hat{\zeta}_t)\upsilon + \hat{\upsilon}_t\Big)\left[\lambda\frac{\frac{1}{\lambda}\int_0^\lambda \hat{L}_t^r(j)dj}{\gamma_r} + (1-\lambda)\frac{\frac{1}{(1-\lambda)}\int_\lambda^1 \hat{L}_t^o(j)dj}{\gamma_o}\right] \end{aligned} \tag{93}$$

We can use equation (19) to substitute $\hat{L}_t^r(j) = \frac{(1-\chi)}{(1-\chi+\upsilon)^2}\frac{1}{L}\hat{\upsilon}_t$, equation (74) to substitute $\hat{C}_t^r$ and equation (75) to substitute $\hat{C}_t^o$. Further, we know that $L_t = \int_o^1 L_t(j)dj = \int_o^\lambda L_t^r(j)dj +$

$\int_{\lambda}^{1} L_t^o(j)dj$, which implies

$$\begin{aligned}\int_{\lambda}^{1} \hat{L}_t^o(j)dj &= \hat{L}_t - \int_0^{\lambda} \hat{L}_t^r(j)dj \\ &= \hat{L}_t - \lambda \frac{(1-\chi)}{(1-\chi+\upsilon)^2}\frac{1}{\bar{L}}\hat{\upsilon}_t \\ &= -\varphi \hat{N}_t - \lambda \frac{(1-\chi)}{(1-\chi+\upsilon)^2}\frac{1}{\bar{L}}\hat{\upsilon}_t. \end{aligned} \tag{94}$$

Substitution into equation (93) and rearranging gives

$$\begin{aligned}U_t &= \lambda \bar{U}^r + (1-\lambda)\bar{U}^o + \left((1+\hat{\zeta}_t)\upsilon + \hat{\upsilon}_t\right)\left[\lambda \frac{(1-\gamma_r)}{\gamma_r(1-\lambda\gamma_r)}\frac{(1-\chi)}{(1-\chi+\upsilon)^2(1-\bar{N})}\hat{\upsilon}_t - \frac{1}{\gamma_o}\varphi\hat{N}_t\right] \\ &\quad +(1+\hat{\zeta}_t)\left\{(1-\chi)\left[\lambda\left(\hat{C}_t + \varphi\hat{N}_t + \frac{(1-\chi)}{1-\chi+\upsilon}\hat{\upsilon}_t\right)\right.\right. \\ &\quad \left.\left. +(1-\lambda)\left(\hat{C}_t - \frac{\lambda}{1-\lambda}\frac{\gamma_r}{\gamma_o}\varphi\hat{N}_t - \frac{\lambda}{1-\lambda}\frac{(1-\chi)\gamma_r}{(1-\chi+\upsilon)\gamma_o}\hat{\upsilon}_t\right)\right] + \chi\hat{G}_t\right\}\end{aligned}$$

From the analysis of an efficient steady-state, we know that $\chi = \gamma_G$ is set by a social planner to ensure efficiency. We assume this to hold henceforth. As usual, we define terms independent of the policy (regime) chosen as *tip*. So far, those are given as

$$\begin{aligned}tip &= \lambda \bar{U}^r + (1-\lambda)\bar{U}^o + \left((1+\hat{\zeta}_t)\upsilon + \hat{\upsilon}_t\right)\left[\lambda \frac{(1-\gamma_r)}{\gamma_r(1-\lambda\gamma_r)}\frac{(1-\gamma_G)}{(1-\gamma_G+\upsilon)^2(1-\bar{N})}\hat{\upsilon}_t\right] \\ &\quad +(1+\hat{\zeta}_t)(1-\gamma_G)\lambda\left(\frac{1-\gamma_r}{1-\gamma_r\lambda}\right)\frac{(1-\gamma_G)}{1-\chi+\upsilon}\hat{\upsilon}_t\end{aligned}$$

The previous considerations allow us to write equation (93) as

$$U_t = (1+\hat{\zeta}_t)\underbrace{\left[(1-\gamma_G)\hat{C}_t + \gamma_G\hat{G}_t\right]}_{=\hat{Y}_t} + \varphi\hat{N}_t\left[(1+\hat{\zeta}_t)(1-\gamma_G)\lambda\frac{1-\gamma_r}{1-\gamma_r\lambda} - \frac{\left((1+\hat{\zeta}_t)\upsilon + \hat{\upsilon}_t\right)}{\gamma_o}\right] + tip. \tag{95}$$

Note that from the resource constraint, we know that $\bar{Y} = \bar{C} + \bar{G}$ must holds. Dividing by $\bar{Y}$, this implies $1 = \gamma_C + \gamma_G$, which yields $\gamma_C = (1-\gamma_G)$. Hence, $(1-\gamma_G)\hat{C}_t + \gamma_G\hat{G}_t = \hat{Y}_t$. Further, we can use

$$\begin{aligned}N_t &= \int_0^1 N_t(j)dj = \int_o^1 \frac{Y_t(j)}{A_t}dj = \frac{Y_t}{A_t}\int_o^1 \frac{Y_t(j)}{Y_t}dj \\ &= \frac{Y_t}{A_t}\int_o^1 \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} dj\end{aligned}$$

and log-linearize which yields $\hat{N}_t = \hat{Y}_t - \hat{A}_t + q_t$, where $q_t = log\left(\int_o^1 \left[\frac{P_t(j)}{P_t}\right]^{-\epsilon} dj\right)$. Using standard results as in Woodford (2003), we know that $q_t = \frac{\epsilon}{2}\sigma_t^2$, where $\sigma_t^2 = \int_0^1 [p_t(j) - p_t]^2 dj$ (where lower case letters p denote second-order log-deviations). Substituting into equation (95), we get

$$\begin{aligned} U_t &= \left[(1+\hat{\zeta}_t)\left(1 + (1-\gamma_G)\lambda\frac{1-\gamma_r}{1-\gamma_r\lambda}\varphi\right) - \frac{\left((1+\hat{\zeta}_t)\upsilon + \hat{\upsilon}_t\right)\varphi}{\gamma_o}\right]\hat{Y}_t \\ &\quad - \left[(1+\hat{\zeta}_t)(1-\gamma_G)\lambda\frac{1-\gamma_r}{1-\gamma_r\lambda} - \frac{\left((1+\hat{\zeta}_t)\upsilon + \hat{\upsilon}_t\right)}{\gamma_o}\right]\varphi\left(\hat{A}_t - \frac{\epsilon}{2}\sigma_t^2\right) + tip. \\ &= \left[(1+\hat{\zeta}_t)\left(1 + (1-\gamma_G)\lambda\frac{1-\gamma_r}{1-\gamma_r\lambda}\varphi - \frac{\upsilon}{\gamma_o}\varphi\right) - \frac{\hat{\upsilon}_t\varphi}{\gamma_o}\right]\hat{Y}_t \\ &\quad - \left[(1+\hat{\zeta}_t)\left((1-\gamma_G)\lambda\frac{1-\gamma_r}{1-\gamma_r\lambda}\varphi - \frac{\upsilon}{\gamma_o}\varphi\right) - \frac{\hat{\upsilon}_t}{\gamma_o}\varphi\right]\left(\hat{A}_t - \frac{\epsilon}{2}\sigma_t^2\right) + tip. \qquad (96) \end{aligned}$$

Let us define $A_1 = \left((1-\gamma_G)\lambda\frac{1-\gamma_r}{1-\gamma_r\lambda}\varphi - \frac{\upsilon}{\gamma_o}\varphi\right)$, where $-1 < A_1 < 0$. This allows us to re-write equation (96) as

$$U_t = \left[(1+\hat{\zeta}_t)(1+A_1) - \frac{\varphi}{\gamma_o}\hat{\upsilon}_t\right]\hat{Y}_t - \left[(1+\hat{\zeta}_t)A_1 - \frac{\varphi}{\gamma_o}\hat{\upsilon}_t\right]\left(\hat{A}_t + \frac{\epsilon}{2}\sigma_t^2\right) + tip.$$

Noting that $\hat{\zeta}_t\hat{Y}_t = \frac{1}{2}\left[\hat{\zeta}_t^2 + \hat{Y}_t^2 - (\hat{Y}_t - \hat{\zeta}_t)^2\right]$ and $\hat{\upsilon}_t\hat{Y}_t = \frac{1}{2}\left[\hat{\upsilon}_t^2 + \hat{Y}_t^2 - (\hat{Y}_t - \hat{\upsilon}_t)^2\right]$, we are able to rearrange this to

$$\begin{aligned} U_t &= \frac{(1+A_1)}{2}\left[(1+\hat{Y}_t)^2 - (\hat{Y}_t - \hat{\zeta}_t)^2\right] - \frac{\varphi}{2\gamma_o}\left[\hat{Y}_t^2 - (\hat{Y}_t - \hat{\upsilon}_t)^2\right] \\ &\quad + \left[(1+\hat{\zeta}_t)A_1 - \frac{\hat{\upsilon}_t\varphi}{\gamma_o}\right]\frac{\epsilon}{2}\sigma_t^2 + \overline{tip}, \qquad (97) \end{aligned}$$

where

$$\overline{tip} = tip - \left[(1+\hat{\zeta}_t)A_1 - \frac{\hat{\upsilon}_t\varphi}{\gamma_o}\right]\hat{A}_t + \frac{(1+A_1)}{2}\hat{\zeta}_t - \frac{\hat{\upsilon}_t\varphi}{2\gamma_o} - \frac{(1+A_1)}{2}$$

is the full set of variables independent of policy. Noting that $\frac{1}{2}\sum_{t=0}^{\infty}\beta^t\sigma_t^2 = \frac{\epsilon}{\kappa}\sum_{t=0}^{\infty}\beta^t\hat{\pi}_t^2$ (see Woodford, 2003) and taking conditional expectations at date zero, the discounted sum of utility streams can be written as equation (46). Note that shock variables multiplied with the inflation deviations are terms of higher order than 2 and are, therefore, neglected.

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