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The debt brake: business cycle and welfare consequences of Germany's new fiscal policy rule

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Abstract:

In a New Keynesian DSGE model with non-Ricardian consumers, we show that automatic stabilization according to a countercyclical spending rule following the idea of the debt brake is well suited both to steer the economy and in terms of welfare. In particular, the adjustment account set up to record public deficits and surpluses serves well to keep the level of government debt stable. However, it is essential to design its feedback to government spending correctly, where discretionary lapses should be corrected faster than lapses due to estimation errors.

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

JEL classification: E 32, G 61, E 62.

Non-technical summary

The possibilities and limits of fiscal policy regarding economic stabilization have moved center stage lately, certainly also prompted by the current economic downturn. In this context, it is continuously stressed that it is necessary to assure sustainability of public finances and the confidence therein. This can be achieved not least by reliable consolidation after the crisis, and - at least in normal times - by rule-based budget requirements. For example, the International Monetary Fund recently identified a possible positive role for rule-based fiscal policy emphasizing that is must be sustainable and reliable if countercyclical fiscal policy is to unfold its desired effects. While in the 1970s, there seemed to be confidence in somewhat active discretionary fiscal policy, further developments have shown that rule-based actions are needed because of reasons revealed in the political economic literature. This insight is also the basis for the fiscal framework of the European (monetary) union.

The focus of the present paper is on the analysis of a rule-based fiscal policy, in particular, the “debt brake”, which is expected to be introduced in Germany soon and has already been implemented in Switzerland. The discussion about the introduction of the debt brake has to be seen in the context of European fiscal rules, namely the European Stability and Growth Pact (SGP). As a rule, the SGP demands roughly balanced budgets in structural terms, while letting the automatic stabilizers take effect. The corrective arm of the pact is called on particularly if the 3% deficit ceiling is violated. The 60% debt ceiling also plays a role. As German national budgetary rules have not been consistent with the European framework, and they were largely assessed as being inappropriate with a view to limiting the increase in public debt, this was the hour of birth of the “Förderalismuskommission II” (federalism reform commission), which recently agreed on a proposal for the DB.

Similar to the SGP, the debt brake demands (almost) structurally balanced budgets and, thus, ties cyclically adjusted government spending (including interest on outstanding debt) to cyclically adjusted trend revenues raised by the government and, therefore, acts as an automatic stabilizer since the government finances some of its expenditures from deficits in “bad times” while accumulating surpluses in ”good times”. In addition to the SGP, the debt brake implements a rule-based feedback of the deficits/surpluses accumulated by the government by booking these on what is called an “adjustment account” and calling for correction by cutting/raising future government spending accordingly. Hence, the main difference between the SGP and the debt brake is the implemented adjustment mechanism by means of the adjustment account.

This analysis explores the business cycle and welfare effects of the debt brake within a macroeconomic DSGE model and compares them to those effects arising under a strict balanced budget rule or under a debt brake with a higher rule-based countercyclical stance. Under a balanced budget rule, the government is only allowed to spend as much as it actually has (or expects to have in the planning period), while the debt brake with a higher countercyclical stance implies an automatic increase or decrease of real government expenditures in phases of recessions and booms. The debt brake is to be allocated somewhere in between.

Within the model framework presented, we can note the following. Due to erratic spending behavior, the balanced budget rule tends to destabilize the economy and gives rise to sunspot equilibria. Cyclical fluctuations tend to be more pronounced under this regime and cyclical smoothing does not take place. In terms of welfare considerations, this regime also does comparatively poorly. The debt brake, even though it ties government spending to trend revenues in principle, results in a positive correlation of government spending (though only mildly) to output fluctuations, which can be attributed to the interest payments on outstanding debt and the commitment to keep the level of debt constant in the long run. For the same reasons, the higher countercyclical stance has only a mildly countercyclical effect, despite being constructed differently. Both rules just discussed act in very similar ways with regards to cyclical smoothing capabilities and welfare. However, the latter rule is the better option within the model framework presented as it generates slightly countercyclical government spending behavior.

The adjustment account and the rule-based feedback to government spending is well suited to generate sustainable government finances with a constant level of debt in the long run - even in the presence of (trend) estimation errors. The paper reveals two potential problems, however. First, the feedback should ideally differ with the shock. More precisely, discretionary government spending shocks ought to be corrected as soon as possible. Second, the stabilizing effects that underlie the basic idea of the debt brake are weakened whenever the level of trend revenues is not estimated correctly.

Nicht-technische Zusammenfassung

Die Möglichkeiten und Grenzen der Finanzpolitik im Hinblick auf eine gesamtwirtschaftliche Stabilisierung stehen in der derzeitigen außergewöhnlichen Krisensituation häufig im Zentrum der wirtschaftspolitischen Diskussion. Dabei wird regelmäßig herausgestellt, dass es auch in diesem Zusammenhang notwendig ist, die Tragfähigkeit der öffentlichen Finanzen bzw. das Vertrauen darin sicherzustellen. Dies kann nicht zuletzt durch eine glaubwürdige Verpflichtung für eine Konsolidierung nach der Krise und das Vorhandensein regelbasierter Haushaltsregeln - zumindest für normalere Zeiten - maßgeblich unterstützt werden. So hat zuletzt der Internationale Währungsfonds die positive Rolle einer regelbasierten Politik der öffentlichen Hand hervorgehoben und betont, dass Tragfähigkeit und Glaubwürdigkeit von entscheidender Bedeutung sind, damit die Finanzpolitik ihre stabilisierende Funktion wahrnehmen kann. Während in den 1970er Jahren auf eine aktivistische, weitgehend ungebundene Finanzpolitik vertraut worden war, wurde im weiteren Verlauf deutlich, dass dies - aufgrund in der politischen Ökonomie beschriebener Mechanismen - zu einem starken Schuldenanstieg führt und eine Regelbindung unabdingbar ist. Diese Erkenntnis lag auch den finanzpolitischen Regeln in der Europäischen Währungsunion zugrunde.

Der Fokus der vorliegenden Analyse liegt auf der Untersuchung von Haushaltsregeln bzw. regelbasierten Fiskalpolitiken. Dabei wird insbesondere eine so genannte "Schuldenbremse" betrachtet, die in Deutschland eingeführt wird und in der Schweiz schon eingeführt wurde. Die Diskussion um die Einführung einer Schuldenbremse steht dabei im engen Zusammenhang mit dem Europäischen Stabilitäts- und Wachstumspakt (SWP). Der SWP verlangt strukturell annähernd ausgeglichene öffentliche Haushalte, während er das Wirkenlassen der automatischen Stabilisatoren zulässt. Der korrektive Arm des Paktes kommt grundsätzlich dann zum Tragen, wenn die Defizit- bzw. die Schuldenobergrenze von 3% bzw. 60% überschritten wird. Da die existierenden nationalen Budgetregeln in Deutschland weder konform zum europäischen Regelwerk waren noch geeignet erschienen, den Anstieg des Schuldenstandes wirkungsvoll zu begrenzen, wurde die Föderalismuskommission II gegründet, die sich kürzlich auf einen Vorschlag zur Implementierung der Schuldenbremse einigte.

Ähnlich wie der SWP verlangt die Schuldenbremse strukturell weitgehend ausgeglichene Budgets und bindet somit die um zyklische Einflüsse bereinigten staatlichen Ausgaben (einschließlich Zinszahlungen auf ausstehende Staatsschuld) an die zyklisch bereinigten (Trend-) Einnahmen des Staates. Somit funktioniert die Schuldenbremse als automatischer Stabilisator, da sie in "schlechten Zeiten" eine Defizitfinanzierung zulässt, wohingegen sie in "guten Zeiten" Überschüsse erfordert. Zusätzlich zum SWP verlangt die Schuldenbremse jedoch im Zeitverlauf eine Kompensation der angefallenen staatlichen Defizite/Überschüsse: Diese werden auf einem Ausgleichskonto verbucht, das langfristig (strukturell) ausgeglichen sein muss, was niedrigere/höhere Staatsausgaben erfordert. Der Unterschied zwischen Schuldenbremse und SWP liegt somit darin, dass in die Schuldenbremse ein direkter Feedbackmechanismus aufgelaufener Schulden oder Überschüsse über das Ausgleichskonto integriert ist.

In dieser Analyse werden die Konjunktur- und Wohlfahrtseffekte verschiedener Haushaltsregeln in einem makroökonomischen DSGE-Modell untersucht. Dabei wird die Schuldenbremse mit einem in jeder Periode ausgeglichenen Haushalt und einer Schuldenbremse mit einer regelgebundenen stärker antizyklischen Komponente verglichen, die häufig in der Literatur verwendet wird. Kontinuierlich ausgeglichene Haushalte implizieren, dass der Staat nur so viel ausgeben darf, wie er einnimmt (bzw. in der Planungsperiode erwartet), wohingegen die regelbasierte antizyklische Komponente in Rezessions- oder Boomphasen automatisch zu mehr bzw. weniger (zyklisch bereinigten) Ausgaben führt. Die Schuldenbremse ist irgendwo in der Mitte dieser beiden Regime anzusiedeln.

Innerhalb des präsentierten Modellrahmens lässt sich feststellen, dass das Regime eines in jeder Periode ausgeglichenen Staatshaushaltes die Volkswirtschaft aufgrund von erratischen Ausgabenverhalten potenziell destabilisiert und sogenannte Sunspot-Gleichgewichte generieren kann. Die konjunkturellen Schwankungen fallen in der Regel stärker aus, und eine Konjunkturglättung findet tendenziell nicht statt. Auch aus Wohlfahrtsgesichtspunkten schneidet diese Regel vergleichsweise schlecht ab. Die Schuldenbremse führt zu einer positiven Korrelation zwischen Staatsausgaben und Outputschwankungen, obwohl sie grundsätzlich die Ausgaben an die Trendeinnahmen bindet, was auf Zinszahlungen auf ausstehende Verschuldung und die mit Hilfe des Ausgleichskonto gemachte Verpflichtung, langfristig ein konstantes Schuldenniveau zu erreichen, zurückzuführen ist. Aus denselben Gründen wirkt die regelgebundene stärkere Stabilisierung, obwohl vom Konstrukt her anders angelegt, nur moderat antizyklisch. Beide Regeln wirken im Hinblick auf ihre Konjunkturglättungseigenschaften sehr ähnlich. Aus Wohlfahrtsgesichtpunkten erscheint jedoch die zuletzt beschriebene Regel innerhalb des präsentierten Modells etwas vorteilhafter.

Das Ausgleichskonto und die regelgebundene Rückführung seines Saldos durch Veränderungen der Staatsausgaben sorgen für eine langfristige Stabilisierung des Schuldenniveaus - auch bei Vorhandensein von (Trend-)Schätzfehlern. Das Papier macht allerdings auf zwei mögliche Probleme aufmerksam: Idealerweise sollte das Feedback vom Ausgleichskonto auf die Staatsausgaben abhängig vom Schock differenziert werden. Insbesondere Salden aufgrund von diskretionären Staatsausgabenschocks sollten schnell abgebaut werden. Zum anderen können die stabilisierenden Effekte der Schuldenbremse geschwächt werden, wenn die erwarteten trendmäßigen Einnahmen falsch eingeschätzt werden.

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1 Introduction

Prompted by the severe current economic downturn, discussions about the potentially stabilizing and welfare-enhancing effects of (active) countercyclical fiscal policy have emerged in the political as well as the academic arena lately. The issue of fiscal sustainability and the necessity of a rule-based framework – at least in unexceptional times – are also stressed in this context. For example, the International Monetary Fund (IMF) recently identified a possible positive role for rule-based fiscal policy in economic cycles in its *World Economic Outlook* (see IMF, 2008, chapter 5), which also shows that if countercyclical fiscal policy is to unfold its desired effect, it must be sustainable and reliable (see also Allsopp and Vines, 2005; and Solow, 2005). While in the 1970s, there seemed to be confidence in active discretionary fiscal policy actions to do the job, further developments have shown that rule-based actions may be necessary because of reasons revealed in the political economic literature (see e.g. Velasco, 1999, 2000, von Hagen, 1992, Harden and von Hagen, 1994, Woo, 2005, or Stähler, 2009, among others).

The focus of the present paper is the analysis of cyclical behavior and welfare effects of a rule-based fiscal policy, in particular, the "debt brake" which is expected to be introduced in Germany soon and has already been implemented in Switzerland. The introduction of the debt brake (in the following "DB") has to be seen not least in the context of European fiscal rules, namely the European Stability and Growth Pact (SGP). As a rule, the SGP demands roughly balanced budgets in structural terms, while allowing for a certain degree of flexibility across the cycle (i.e. letting the automatic stabilizers take effect). The corrective arm of the pact is called on particularly if the 3% deficit ceiling is violated (the 60% debt ceiling also plays a role; see also European Commission, 2001). Such a construction should safeguard fiscal sustainability, while at the same time allowing the automatic stabilizers to play fully. German national budgetary rules have not been consistent with the European framework, and they were largely assessed as being inappropriate with a view to limiting the increase in public debt. This was the hour of birth of the "Förderalismuskommission II" (federalism reform commission), which recently agreed on a proposal for the DB.

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Similar to the SGP, the DB demands (almost) structurally balanced budgets and, thus, ties cyclically adjusted government spending (including interest on outstanding debt) to cyclically adjusted trend revenues raised by the government and, therefore, acts as an automatic stabilizer since the government finances some of its expenditures from deficits in "bad times" while accumulating surpluses in "good times". In addition to the SGP, the DB implements a rule-based feedback of the deficits/surpluses accumulated by the government by booking these on an "adjustment account" and calling for correction by cutting/raising future government spending accordingly. For symmetric shocks, this rule should generate a (pre)determined 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). Hence, leaving aside some different thresholds regarding debt and deficit limits, the main difference between the SGP and the DB is the implemented adjustment mechanism by means of the adjustment account.

The present paper, to the best of our knowledge the first, analyzes business cycle dynamics and welfare effects of the DB in a DSGE model and compares them with a strict balanced budget rule demanding balanced budgets each period (in the following BB) as well as with a debt brake with a more countercyclical stance (in the following AS), which, in addition to only tying government spending to trend revenues, gives a more pronounced countercyclical impulse depending on the current cyclical situation. For all of the rules under consideration, we assume that there is an adjustment account. While BB rules do indeed exist, for example in most US states[2], the AS reflects - to a certain extent – how automatic stabilizers have conventionally been modelled in the literature (see e.g. Taylor, 2000).[3] The DB is, therefore, somewhere in between a BB and an AS regime. In this analysis, we will discover the key elements of the DB and how recent rules may be improved in their design from the perspective of the model presented. The model is in the manner of Gali et al. (2007) and Leith and Wren-Lewis (2007) 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 DB, BB or AS, respectively. Our general finding is that a rule which steers fiscal expenditures along the trend path and abstains from activism seems preferable as it smoothes economic developments by preserving fiscal sustainability.

The BB potentially destabilizes the economy and gives rise to sunspot equilibria. Due to erratic spending schemes, the BB regime triggers boom-bust cycles in consumption among non-Ricardian households. As monetary authorities do not have leverage on these hand-to-mouth consumers, such a fiscal policy stance may even generate sunspot equilibria if the central bank adopts the Taylor principle (see also Gali, 2004). Accordingly, the overall welfare loss would increase by 7.2% if fiscal authorities were to switch from a DB to a BB.

[2]In principle, US states follow a BB rule. However, some of them have set up a "rainy day fund", which may, under certain circumstances, allow for countercyclical fiscal policy (see Rodriguez-Tejedo, 2006; for an overview).

[3]Note that the AS and the DB are both automatic stabilizers, only that the former has a more pronounced reaction to cyclical fluctuations.

The DB acts countercyclically by construction in the sense that, as government spending is, in principle, fixed to trend revenues, spending is relatively lower in good times and vice versa. This countercyclical stance is, however, diminished, and we find that government spending is positively – albeit only mildly – correlated with the cyclical fluctuations in GDP. This can be attributed to the interest payments on outstanding debt and to the commitment to keeping overall debt constant over time, i.e. to the feedback from the adjustment account. For a shock positively influencing actual government revenue, this implies that these additional funds are gradually spent over time. The AS regime explicitly necessitates stabilization in output which augments the countercyclical stance compared to the DB regime. Indeed, we find that government spending in such a regime moves in an opposite direction to the cyclical movements in GDP. But the countercyclical stance of government spending is also only relatively small in the AS regime, which can again be attributed to interest on outstanding debt and the adjustment account as is the case for the DB regime. Hence, the difference between the two regimes lies in the fact that government spending moves with the cycle of GDP in the DB regime and opposite to the cycle of GDP in the AS regime. Both regimes can still be considered countercyclical because of generally keeping government spending to a large extent independent of revenues and, not surprisingly from the construction of the spending rules, differ only in their countercyclical stance.

In terms of welfare, calculated as an average consumer loss function for the aggregated shocks, a DB and AS regime are very comparable as the welfare difference is limited to only 2.8%. Nevertheless, the AS is the DSGE winner because it keeps expenditures a little closer to trend revenues than the DB itself and, therefore, attenuates the adverse effects of government spending on wages as it does not crowd in private consumption as much as the DB. Only if we analyze the welfare effects for each shock separately do we find that, for a cost-push shock, the BB may be the preferable option. The reason is that the cost-push shock boosts inflation while decreasing output and tax revenues, which reduces government spending. The (additional) decrease in aggregate demand and the resulting anti-inflationary stance is found to be welfare enhancing as inflation volatility – the main driver of the welfare loss – is diminished.

With regard to the adjustment account, we find that the feedback of real government spending should ideally differ with the shock. Discretionary government spending shocks should be corrected as soon as possible, while all other shocks (generating expectation errors) should fade out slowly over time in order to keep those fluctuations actively introduced into the system low. We should stress at this point that trend revenue is assumed to be known in our basic model, while estimating trend is a difficult task in practice. Taking into account possible estimation errors when simulating our model, we find that the adjustment account is well suited to prevent debt from dramatically increasing, while equally stabilizing inflation and output whenever the feedback is set optimally. If the feedback is set too low, the economy is subject to more pronounced cycles in GDP and inflation and, thus, welfare losses.

Related literature: 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 tax distortions, it may even become negative, see Sutherland, 1997, and Hemming et al., 2002). The fact that, empirically, there was and still is much evidence to suggest that fiscal multipliers 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, 2006, 2007, Leith and von Thadden, 2008, and Stehn and Vines, 2008). Another strand of literature on fiscal policy in DSGE models has tended to focus on the cyclical impact rather than debt feedback (as, for example, also in, Taylor, 2000, Auerbach, 2002, and Favero and Monacelli, 2005), while only recently, the discussion about simple stabilizing fiscal rules related to debt, their optimal design and, partly, their strategic interaction with monetary policy has been taken up (see e.g. Kirsanova and Wren-Lewis, 2007, Kirsanova et al. 2005, 2007, and Fragetta and Kirsanova, 2007). Starting with Benigno and Woodford (2003), Schmitt-Grohé and Uribe (2007) or Linnemann and Schabert (2008), the studies discuss optimal fiscal policy (and the interaction with monetary policy) whenever fiscal authorities can commit to a certain policy. In contrast, we explicitly assume that there are no commitment technologies such as commitment under a timeless perspective or optimal Ramsey plans available – also due to the political incentives hinted at earlier. Rather, we assume that fiscal authorities are pledged towards a constant debt-to-GDP ratio in the long run (i.e. in the steady state in our model) which necessitates a fiscal rule. Thus we exclude by assumption that debt follows a random walk as it is optimal under commitment, and we construct a model that reconciles the reactions of macroeconomic variables to a fiscal policy shock found empirically. Gali et al. (2007) show that this happens in DSGE models with rule-of-thumb consumers as well as sticky prices and deficit financing. Straub and Tchakarov (2007), Leith and Wren-Lewis (2007) and Gali and Monacelli (2008) find that countercyclical fiscal policy – a feature of the DB and AS regime – may be welfare enhancing in such set-ups. The main reason is that such fiscal actions help to at least partly internalize the externalities caused by the implemented rigidities and market imperfection, and to keep fluctuations in inflation and disutility of labor smaller than without stabilization. Mayer and Grimm (2008) agree that countercyclical tax rules can improve welfare for supply-side shocks. They show that this is even the case for balanced budget rules if the tax rule is contingent on the observed output gap or on the shock. This paper contributes to the debate by discussing different spending rules in a commonly used macroeconomic model among which some rules are indeed implemented in practice. We further point out which key elements have to be taken into account when designing such rules.

Section 2 introduces the model 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 some important policy issues. Section 6 concludes.

2 The model

In this section, we present a New Keynesian DSGE model with firms and households as well as monetary and fiscal authorities. As standard, firms are categorized into the final goods sector and a continuum of intermediate goods 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 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 their total labor income each period. 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 DB, the AS regime or the BB rule. The model is built on the framework of Gali, et al. (2007), Leith and Wren-Lewis (2007), and Mayer and Grimm (2008).

In what follows, any aggregate variable X_t is defined by a weighted average of the corresponding variables for each consumer type, i.e., in general, $X_t = \lambda X_t^r + (1-\lambda)X_t^o$, where the superscripts o and r stand for optimizing 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 given by $\hat{X}_t = log\left(X_t/\bar{X}\right) \approx (X_t - \bar{X})/\bar{X}$. As the model is quite standard (except for the fiscal regime), most calculations have been relegated to the appendix, whereas the main text only states the equations of origin and the resulting outcomes.

2.1 Firms and price setting

2.1.1 Final goods producers

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

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

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 $j \in (0,1)$

$$Q_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon_t} Y_t. \tag{2}$$

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 $\Phi_t = \frac{\epsilon_t}{(\epsilon_t - 1)}$ reflects the time-varying mark-up in the goods market. We get $\Phi_t = \Phi + \hat{\Phi}_t$, where we assume that $\hat{\Phi}_t$ is i.i.d. normally distributed. Then, $\Phi = \frac{\epsilon}{(\epsilon-1)}$ is the deterministic mark-up in the steady state.

2.1.2 Intermediate goods producers and prices

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

$$\Pi_t(j) = P_t(j)Q_t(j) - W_t(1-\tau_n^s)N_t(j), \tag{3}$$

where W_t denotes the nominal wage rate and N_t are labor services rented by firms. The production technology available to firms is given by

$$Q_t(j) = A_t \cdot N_t(j), \tag{4}$$

in which labor is the sole input. For analytical simplicity, it is linear in the shock, where $\bar{A} = 1$. We assume staggered price setting which implies that only a fraction $(1-\theta_P)$ of firms is able to adapt prices, where θ_P is the Calvo parameter (see Calvo, 1983). Additionally, firms receive constant employment subsidies τ_n^s on gross labor costs $W_t N_t(j)$ which undoes the distortions associated with monopolistic competition and the tax wedge in the steady state such that we are able to take a second order approximation around the efficient steady state later on without altering the dynamics of the model (for more details, see also Gali and Monacellli, 2008, and Leith and Wren-Lewis, 2007, among others). The subsidies are financed by lump-sum taxes which are levied on optimizing households.

2.2 The household sector

We assume a continuum of households indexed by $j \in (0,1)$ of which $(1-\lambda)$ households 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 (in the following also called rule-of-thumb consumers). Let us assume that any household j is characterized by the following lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t U_t^i \left(C_t^i(j), L_t^i(j)\right), \tag{5}$$

where $i = o, r$ indicates optimizing and rule-of-thumb households, respectively. The per-period utility function for all households is given by

$$U_t^i(j) = \zeta_t \left[(1-\chi) log \left(C_t^i(j)\right) + \chi log\left(G_t\right) + \upsilon log\left(L_t^i(j)\right)\right], \tag{6}$$

where ζ_t is a common preference shock, with $E\{\zeta_t\} = \bar{\zeta} = 1$. $L_t^i(j)$ is household j's leisure, where $N_t^i(j) = 1 - L_t^i(j)$ gives the corresponding labor supply of household j. $\upsilon > 0$ measures how leisure is valued compared to consumption $C_j^i(j)$. $\chi \in (0, 1)$ measures the relative utility weight given to public goods consumption G_t.

2.2.1 Optimizing households

The flow budget constraint of optimizing households in real terms is given by

$$(1+\tau_t^C)C_t^o(j) + \frac{B_{t+1}^o(j)}{P_t} - T_t^{s,n} \leq (1-\tau_t^d)\frac{W_t}{P_t}N_t^o(j) + \frac{\Pi_t^o(j)}{P_t} + \frac{B_t^o(j)}{P_t}R_{t-1}, \tag{7}$$

where B_{t+1} 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 goods sector. τ_t^d is a distortionary tax rate levied on nominal labor income, while τ_t^C is a consumption (quasi-value added) tax. $T_t^{s,n}$ denotes the lump-sum tax levied on optimizing households to finance the constant employment subsidy τ_n^s.

Each optimizing household maximizes its utility, equation (5) – given equation (6) – with respect to consumption, leisure and bond holdings subject to the intertemporal version of the budget constraint, equation (7). We find that (see Appendix C)

$$\frac{\zeta_t}{C_t^o(j)} = \beta R_t E_t \left\{ \frac{1+\tau_t^C}{1+\tau_{t+1}^C} \cdot \frac{\zeta_{t+1}}{C_{t+1}^o(j)} \cdot \frac{P_t}{P_{t+1}} \right\} \tag{8}$$

is the consumption Euler equation for optimizing households and derive

$$\frac{C_t^o(j)}{L_t^o(j)} = \frac{(1-\chi)}{\upsilon} \cdot \frac{(1-\tau_t^d)}{(1+\tau_t^C)} \cdot w_t \tag{9}$$

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

The lifetime utility of rule-of-thumb consumers is also given by equations (5) and (6). However, as they do not have access to the capital market, their budget constraint becomes static and is given by

$$(1+\tau_t^C)C_t^r(j) = (1-\tau_t^d)\frac{W_t}{P_t}N_t^r(j), \tag{10}$$

which implies that they spend all their per-period income. Hence, rule-of-thumb consumers maximize equation (5) – given equation (6) – with respect to $C_t^r(j)$ and $L_t^r(j)$ subject to the intertemporal version of the static budget constraint, equation (10). We get (see Appendix C)

$$\frac{C_t^r(j)}{L_t^r(j)} = \frac{(1-\tau_t^d)}{(1+\tau_t^C)} \frac{(1-\chi)}{\upsilon} w_t, \tag{11}$$

which, substituted in equation (10) and remembering that $N_t^r = 1 - L_t^r$, yields

$$N_t^r(j) = \frac{(1-\chi)}{(1-\chi)+\upsilon} \;\Leftrightarrow\; L_t^r(j) = \frac{\upsilon}{(1-\chi)+\upsilon}. \tag{12}$$

Hence, labor supply by rule-of-thumb consumers is exogenously fixed by the parameter υ, which values leisure compared to consumption, and by $(1-\chi)$, which gives the relative weight of private consumption. Using equation (12) and equation (11), we find that

$$C_t^r(j) = \frac{(1-\chi)}{(1-\chi)+\upsilon} \cdot w_t \cdot \frac{(1-\tau_t^d)}{(1+\tau_t^C)}. \tag{13}$$

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 taxes $\tau_t^d W_t N_t$. 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 R_{t-1} is the gross interest rate. Furthermore, the government has to pay subsidies on labor costs for which it also collects the corresponding lump-sum taxes. Hence, the government's flow budget constraint reads

$$B_{t+1} + (\tau_t^d + \tau_n^s) W_t N_t + \tau_t^C P_t C_t = R_{t-1} B_t + P_t G_t + T_t^{s,n}. \tag{14}$$

At each point in time, it holds that $\tau_n^s W_t N_t = T_t^{s,n}$ such that it cancels out in equation (14); see also Leith and Wren-Lewis (2007). Simplifying accordingly, expressing equation (14) in real terms and normalizing by $\bar{Y}$, where $\bar{Y}$ is the steady-state output, yields

$$\frac{B_{t+1}}{P_t \bar{Y}} + \frac{\tau_t^d w_t N_t}{\bar{Y}} + \frac{\tau_t^C C_t}{\bar{Y}} = \frac{R_{t-1} B_t}{P_{t-1} \bar{Y}} \frac{P_{t-1}}{P_t} + \frac{G_t}{\bar{Y}}. \tag{15}$$

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

$$\frac{\Psi_t}{P_t \bar{Y}} = \frac{\tau_t^d w_t N_t}{\bar{Y}} + \frac{\tau_t^C C_t}{\bar{Y}}, \tag{16}$$

equation (15) rewrites to

$$\tilde{b}_{t+1} + \frac{\Psi_t}{P_t \bar{Y}} = R_{t-1} \tilde{b}_t \frac{P_{t-1}}{P_t} + \frac{G_t}{\bar{Y}}. \tag{17}$$

For later use, we will further define

$$b_t = \tilde{b}_t - \bar{b} = \frac{B_t}{P_{t-1}\bar{Y}} - \frac{\bar{B}}{\bar{P}\bar{Y}} \tag{18}$$

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 The balanced budget rule (BB)

As a benchmark for a sustainable spending rule, we introduce a BB, 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. Any expectation errors, i.e. differences between projected and actual funds raised and (active) discretionary spending shocks ν_t are booked on the adjustment account AC_t to record lapses in spending behavior. Thus, (ex-ante) spending according to the BB 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 $\rho \in [0, 1]$ is a parameter indicating how much of an effect earlier lapses in the spending behavior have on current spending. It can be interpreted as the speed of adjustment. This implies that actual (ex-post) spending is given by $(R_{t-1} - 1)B_t + P_t G_t = E_{t-1}\{\Psi_t\} - \rho AC_{t-1} + \nu_t$. The adjustment account for the balanced budget rule reads $AC_t = (1 - \rho)AC_{t-1} + \nu_t + E_{t-1}\{\Psi_t\} - \Psi_t$. In normalized real terms, for the budget constraint, this reads

$$(R_{t-1} - 1)\tilde{b}_t + \frac{G_t}{\bar{Y}} = \underbrace{E_{t-1}\left\{\frac{\Psi_t}{P_t\bar{Y}}\right\} - \rho \cdot \frac{P_{t-1}}{P_t} \cdot ac_{t-1}}_{=Rule-based\ spending} + \frac{\nu_t}{P_t\bar{Y}} \tag{19}$$

and, for the adjustment account,

$$ac_t = (1 - \rho)\frac{P_{t-1}}{P_t} \cdot ac_{t-1} + \frac{\nu_t}{P_t\bar{Y}} + \underbrace{E_{t-1}\left\{\frac{\Psi_t}{P_t\bar{Y}}\right\} - \frac{\Psi_t}{P_t\bar{Y}}}_{Expectation\ error}, \tag{20}$$

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

2.3.2 The debt brake (DB) and additional rule-based stabilization (AS)

As described in the introduction, the main idea of the DB is that real spending including interest on outstanding real debt, i.e. $(R_{t-1} - 1)\frac{B_{t+1}}{P_t} + G_t$, must be equal to real trend revenues, i.e. $\frac{\bar{\Psi}}{\bar{P}}$, which yields a countercyclical fiscal stance as surpluses arise in "good times" and deficits in "bad times". Within the AS regime, government spending increases (relatively) with negative output fluctuations (and vice versa), which is how automatic stabilization has often been modelled previously (see e.g. Taylor, 2000; Artis and Buti, 2000; or Buti et al., 2001). In order to make this rule comparable to the DB, we assume that, in the steady-state, both rules are tied to steady-state revenues (which implies that $\frac{\bar{\Psi}}{\bar{P}}$ is regarded as a fixed constant in the AS regime). However, the higher countercyclical stance of the AS augments the rule-based spending by $E_{t-1}\left\{\left(\bar{Y}/Y_t\right)^{\alpha}\right\}$, where $\alpha > 0$ captures the magnitude of the stance taken by the rule. This implies relatively more spending in expected "bad times", $Y_t < \bar{Y}$, and vice versa. The discussion can formally be summarized (in normalized real terms) by

$$(R_{t-1}-1)\tilde{b}_t + \frac{G_t}{\bar{Y}} = \underbrace{\frac{\bar{\Psi}}{\bar{P}\bar{Y}} \cdot E_{t-1}\left\{\left(\frac{\bar{Y}}{Y_t}\right)^{\alpha}\right\} - \rho \cdot \frac{P_{t-1}}{P_t} ac_{t-1}}_{=Rule-based\ spending} + \frac{\nu_t}{P_t\bar{Y}}, \tag{21}$$

where ν_t is a (discretionary) government spending shock and ac_t and ρ depict the adjustment account (see also below) and the speed of adjustment. Furthermore, it holds that $\alpha = 0$ for the DB and $\alpha > 0$ for the AS. Note, from a theoretical perspective, fiscal authorities should, of course, try to replicate the allocation under flexible prices, such that (Y_t^{flex}/Y_t) is a relevant measure to stabilize. However, in the political debate, fiscal authorities act as if they try to stabilize output around a smoothed trend, which we identify as the steady-state value $\bar{Y}$ in our model. Within this paper, we do not attempt to measure the welfare loss which can be attached to such a behavior.

Regarding the adjustment account, we know that a discretionary spending shock ν_t must reduce future spending as in the case for the BB. As the DB ties spending to trend revenues, any deficit resulting from deviations of true revenues from trend revenues have to be repatriated in future periods and the adjustment account books $\frac{\bar{\Psi}}{\bar{P}\bar{Y}} - \frac{\Psi_t}{P_t Y_t}$. For the AS, the deviations of output from trend output determine spending behavior. Hence, deviations of the additional spending, i.e. $E_{t-1}\left\{\left(\bar{Y}/Y_t\right)^{\alpha}\right\}$, have to be booked on the adjustment account in order to generate a constant level of debt. It thus formally holds that

$$\begin{aligned} ac_t &= (1-\rho) \cdot \frac{P_{t-1}}{P_t} \cdot ac_{t-1} + \frac{\nu_t}{P_t\bar{Y}} + \underbrace{\varrho\left[\frac{\bar{\Psi}}{\bar{P}\bar{Y}} - \frac{\Psi_t}{P_t\bar{Y}}\right]}_{Booking\ DB;\ \alpha=0,\ \varrho=1} \\ &\quad - \frac{\bar{\Psi}}{\bar{P}\bar{Y}} \cdot \underbrace{E_{t-1}\left\{\left(\bar{Y}/Y_t\right)^{\alpha}\right\}}_{Booking\ AS;\ \alpha>0,\ \varrho=0}, \end{aligned} \tag{22}$$

where $\varrho = 1$ for the DB and $\varrho = 0$ for the AS (note that α applies according to the spending rule).[4]

[4]Note that as the government is committed towards keeping real debt constant in the long run, debt services and the adjustment account can almost cancel out the AS component such that the fiscal stance might only move moderately countercyclical to GDP.

2.4 Market clearance

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

$$Y_t = C_t + G_t, \tag{23}$$

where $C_t = \lambda C_t^r + (1-\lambda)C_t^o$ is aggregate consumption.[5] Furthermore,

$$Y_t(j) = Q_t(j) \tag{24}$$

and (in per capita units)

$$N_t = \frac{1}{\lambda}\int_0^\lambda N_t^r(j)dj + \frac{1}{(1-\lambda)}\int_\lambda^1 N_t^o(j)dj. \tag{25}$$

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 (for mathematical derivations, see Appendix B): From the firm sector, we find that the log-linearized marginal cost function is given by

$$\hat{mc}_t(i) = -\hat{A}_t + \hat{w}_t. \tag{26}$$

From the production technology, equation (4), we know that

$$\hat{N}_t = \hat{Y}_t - \hat{A}_t. \tag{27}$$

Solving the firm's optimality condition for the optimal reset price and following Gali et al. (2001), we can derive the Phillips curve

$$\hat{\pi}_t = \beta \cdot E_t\left\{\hat{\pi}_{t+1}\right\} + \kappa \cdot \hat{mc}_t + \hat{\epsilon}_t, \tag{28}$$

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 (for mathematical derivations, see Appendix C): The log-linearized version of the aggregate consumption Euler equation expressed in deep parameters reads

$$\hat{C}_t = E_t\hat{C}_{t+1} - \Theta_n E_t\Delta\hat{N}_{t+1} + \iota^C E_t\Delta\hat{\tau}_{t+1}^C - E_t[\hat{R}_t - \hat{\pi}_{t+1}] + E_t[\hat{\zeta}_t - \hat{\zeta}_{t+1}], \tag{29}$$

[5]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).

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

$$\hat{w}_t = \hat{C}_t + \varphi\hat{N}_t + \iota^d\hat{\tau}_t^d + \iota^C\hat{\tau}_t^C, \tag{30}$$

where $\iota^d \equiv \frac{\bar{\tau}^d}{(1-\bar{\tau}^d)}$.

Fiscal authorities (for mathematical derivations, see Appendix D): Log-linearizing the normalized budget constraint, equation (17), around its steady state yields

$$b_{t+1} - \beta^{-1}b_t = \gamma_G \underbrace{\left[\hat{G}_t - (\hat{\Psi}_t - \hat{P}_t)\right]}_{=Primary\ deficit} + \bar{\tilde{b}}\underbrace{\left(1-\beta^{-1}\right)}_{<0}\left[\hat{\Psi}_t - \hat{P}_t\right] + \bar{\tilde{b}}\beta^{-1}\left[\hat{R}_{t-1} - \hat{\pi}_t\right]. \tag{31}$$

Equation (31) determines the evolution of the level of debt after a deviation of other parameters. Real government revenues evolve according to

$$\hat{\Psi}_t - \hat{P}_t = \underbrace{\frac{\bar{\tau}^d\bar{W}\bar{N}}{\bar{\Psi}}}_{=Rev^L}\left(\hat{\tau}_t^d + \hat{w}_t + \hat{N}_t\right) + \underbrace{\frac{\bar{\tau}^C\bar{P}\bar{C}}{\bar{\Psi}}}_{=Rev^{VAT}}\left(\hat{\tau}_t^C + \hat{C}_t\right), \tag{32}$$

where $Rev^L = \frac{\bar{\tau}^d(\epsilon-1)}{\epsilon(1-\tau_n^s)[\gamma_G-(1-\beta^{-1})\bar{\tilde{b}}]}$ and $Rev^{VAT} = \frac{\bar{\tau}^C}{\gamma_C[\gamma_G-(1-\beta^{-1})\bar{\tilde{b}}]}$ are the percentages of labor tax revenue and of value added tax revenue calculated in deep parameters, respectively. Note that $Rev^L + Rev^{VAT} = 1$ (see Appendix E for more details). Equation (32) thus determines the deviation of government revenue from its steady-state value.

Log-linearized government spending is given by

$$\begin{aligned}\hat{G}_t = \quad & \frac{(1-\beta^{-1})}{\gamma_G}b_t - \frac{\rho}{\gamma_G}\cdot ac_{t-1} + \frac{1}{\gamma_G\bar{P}\bar{Y}}\cdot\nu_t + \frac{\bar{\tilde{b}}(1-\beta^{-1})}{\gamma_G}\hat{\pi}_t - \beta^{-1}\frac{\bar{\tilde{b}}}{\gamma_G}\hat{R}_{t-1} \\ & + \frac{\gamma_G - (1-\beta^{-1})\bar{\tilde{b}}}{\gamma_G}\underbrace{\left[\varnothing_1\cdot\underbrace{E_{t-1}\left\{\hat{\Psi}_t - \hat{P}_t\right\}}_{BB} - \alpha\cdot\underbrace{E_{t-1}\left\{\hat{Y}_t\right\}}_{AS}\right]}_{=0\ for DB},\end{aligned} \tag{33}$$

while the log-linearized adjustment account is given by

$$\begin{aligned}ac_t \;&=\; (1-\rho)ac_{t-1} + \frac{\nu_t}{\bar{P}\bar{Y}} + \left(\gamma_G - (1-\beta^{-1})\bar{\tilde{b}}\right)\left[\left(\varnothing_1\cdot E_{t-1}\left\{\hat{\Psi}_t\right\} - \varrho\hat{\Psi}_t\right)\right. \\ & \left. - \left(\varnothing_1\cdot E_{t-1}\left\{\hat{P}_t\right\} - \varrho\hat{P}_t\right) + \alpha E_{t-1}\left\{\hat{Y}_t\right\}\right],\end{aligned} \tag{34}$$

where $\varnothing_1 = \alpha = 0$ and $\varrho = 1$ for the DB, $\varnothing_1 = \varrho = 0$ and $\alpha > 0$ for the AS and $\varnothing_1 = \varrho = 1$ and $\alpha = 0$ for the BB.

Proposition 1. *Define a linear combination of variables as indicated by equation (34). Assume for the sake of exposition that the economy is driven by a set of orthogonal white noise error terms* η_t*. Then,* $ac_t = (1-\rho)ac_{t-1} + \eta_t$ *will be non-stationary if* $\rho = 0$ *across all regimes.*

Proof. By backward induction, it holds that

$$\begin{aligned} ac_t &= (1-\rho)^{\infty} ac_{t-\infty}^{\infty} + \sum_{k=0}^{\infty} (1-\rho)^k \frac{\nu_{t-k}}{\bar{P}\bar{Y}} + \varnothing_2 \left(\gamma_G - (1-\beta^{-1})\bar{\bar{b}}\right) \sum_{k=0}^{\infty} (1-\rho)^k \epsilon_{DB,t-k} \\ &+ \varnothing_3 \alpha \left(\gamma_G - (1-\beta^{-1})\bar{\bar{b}}\right) \sum_{k=0}^{\infty} (1-\rho)^k \epsilon_{AS,t-k} \\ &+ \varnothing_4 \left(\gamma_G - (1-\beta^{-1})\bar{\bar{b}}\right) \sum_{k=0}^{\infty} (1-\rho)^k \epsilon_{BB,t-k}, \end{aligned}$$

where $\epsilon_{DB,t} = -\left\{\hat{\Psi}_t - \hat{P}_t\right\}$, $\epsilon_{AS,t} = E_{t-1}\left\{\hat{Y}_t\right\}$ and $\epsilon_{BB,t} = E_{t-1}\left\{\hat{\Psi}_t - \hat{P}_t\right\} - \left\{\hat{\Psi}_t - \hat{P}_t\right\}$ are white noise processes with $\varnothing_2 = 1$, $\varnothing_3 = \varnothing_4 = 0$ for the DB, $\varnothing_3 = 1$, $\varnothing_2 = \varnothing_4 = 0$ for the AS and $\varnothing_4 = 1$, $\varnothing_2 = \varnothing_3 = 0$ for the BB. It holds that ac_t will be stationary if $0 < |\rho| < 1$, as all sums are bounded. □

Proposition 1 states that even if shocks are symmetrically distributed, they will not cancel each other out over the business cycle such that ac_t will be a non-stationary variable for $\rho = 0$. Thus, the pure existence of exceptional errors is sufficient to justify a partial feedback from the adjustment account to government spending as business cycle dynamics will not render ac_t stationary by itself. This result is important because, in the political debate, there seems to be the conjecture that a sustainable fiscal policy is a necessary and sufficient condition for stationarity – which is not the case in our model.

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

$$\hat{R}_t = (1-\mu)\left[\phi_\pi \hat{\pi}_t + \phi_Y \hat{Y}_t\right] + \mu \hat{R}_{t-1} + z_t, \tag{35}$$

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

$$\hat{Y}_t = \gamma_C \hat{C}_t + \gamma_G \hat{G}_t, \tag{36}$$

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).

Shocks: 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. Hence, equations (26) to (36), as well as the shock rules, describe the economy.

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

Proof. See Appendix E. □

Remark 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

When 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 tax rates, in particular, such that the level of public to private consumption is roughly speaking one to three as in the euro area. The labor tax rate is set to $\bar{\tau}^d = 0.10$. The consumption tax rate is calibrated to be $\bar{\tau}^C = 0.18$ (see Coenen, Mohr and Straub, 2008). This endogenously determines the private consumption to output ratio and the government consumption to output ratio which are equal to $\gamma_C = 0.74$ and $\gamma_G = 0.26$.[6]

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, this can replicate a crowding in of private consumption, which is in line with evidence reported from a VAR by Gali et al. (2007). For lower values of λ as, for instance, proposed by Coenen, McAdam and Straub (2008), our model would still predict a substantial crowding out in private consumption which might be considered counterfactual.

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, we choose

[6]Recall that the DB does not encompass the social security system.

the parameter such that our welfare metric, which is discussed in section 4, is minimized. We find in particular that for all shocks, except government expenditure shocks, the algorithm preferred rather small parameters for ρ. Accordingly, we set $\rho = 0.05$, which generates a unique and determined rational expectations equilibrium.[7]

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 somewhere in the middle of the range typically reported in the literature. Coenen, McAdam and Straub (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 goods producers over marginal cost is set at 10 per cent, implying that $\epsilon = 11$.

Following Gali et al. (2007), who specify the household sector in a similar setting to ours (i.e. a log-utility function), we calibrate the inverse of the Frisch elasticity of labor supply equal to $\varphi = 1$. The discount factor is fixed to $\beta = 0.99$, implying a 4% steady-state real interest rate.

The Taylor rule coefficients display values in line with Schmitt-Grohé and Uribe (2007). The inflation coefficient is set to $\phi_\pi = 3.0$, while for the output gap coefficient, we opt for

[7]More concretely, we proceed as follows. Assuming that the fundamental shocks (technology shocks (TS), shocks to consumer preferences (CPS), price mark-up shocks (PMS), monetary shocks (MS) and fiscal spending shocks (FS)) are orthogonal as standard in the literature, we can decompose the welfare loss function as a linear combination of the structural shocks, i.e $\mathbb{W}_0(\rho) = \mathbb{W}_0^{TS}(\rho) + \mathbb{W}_0^{CPS}(\rho) + \mathbb{W}_0^{PMS}(\rho) + \mathbb{W}_0^{MS}(\rho) + \mathbb{W}_0^{FS}(\rho)$, where all parameters are fixed at their baseline value except ρ. Then, we continue by calculating $\mathbb{W}_0(\rho)$, where ρ is defined over the following tuple $[0.00, 0.05, 0.10, 0.15, 0.20]$. While conducting this exercise we find that the welfare loss metric $\mathbb{W}_0(\rho)$ takes its lowest value for $\rho = 0.05$, which we take as our baseline value. A more sophisticated approach would be finding the globally optimal value for each fundamental shock by, for example, the *MATLAB* routine *fmincon*, which finds a constrained minimum of a scalar function, starting from an initial estimate. In Appendix A.1, we report the outcome of such an exercise graphically. It suggests that, if ρ could be fine-tuned towards a specific shock, the value optimally differed with the shock. If movements in the adjustment account can be traced back to technology or price mark-up shocks, fiscal authorities are well advised not to correct fiscal expenditures to sharply in the following period. For the case of fiscal, monetary and consumer preference shocks, the recommendation is somewhat reversed. If fiscal authorities are the source of economic disturbance, the welfare metric reports evidence that a sharper correction in the following period is appropriate as the relative damage imposed on the consumer can be reduced by a factor of four compared to the case in which fiscal authorities only moderately respond to past lapses in expenditures. For the case of consumer preference and monetary shocks, the welfare metric can be reduced by 10% if fiscal authorities move from a very low feedback ($\rho = 0.01$) to a somewhat higher feedback ($\rho = 0.05$). To be in line with debt brakes actually implemented in Switzerland or which are planed to be implemented in Germany, we assume that the government has no technology at hand to find-tune the response of the adjustment account towards the specific shock and thus set to $\rho = 0.05$ for all shocks, which is – on average – the best response to movements in the adjustment account.

$\phi_Y = 0.25$ (see Del Negro et al., 2005; Coenen, Mc Adam and Straub, 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. Additionally, Schmitt-Grohé and Uribe (2007) report evidence that values well above 1.5 are welfare enhancing in economies with nominal frictions and hence set $\phi_\pi = 3.0$. The interest rate smoothing coefficient is set to $\mu = 0.85$.

The exogenous driving forces ζ_t, A_t, z_t and ϵ_t are assumed to follow a univariate autoregressive process where the first order coefficients are set as follows: $\rho_\zeta = 0.882$, $\rho_\epsilon = 0.890$, $\rho_z = 0.150$ and $\rho_A = 0.822$. These values reflect coefficients found in Coenen, McAdam and Straub (2008) 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 autocorrelated fiscal expenditure shocks such as Smets and Wouters (2004) with $\rho_v = 0.956$, Chari et al. (2007) attribute only a small role to fiscal expenditure shocks, if at all. Others estimate DSGE models and remain tacit as to whether there is any role for fiscal expenditure shocks by not specifying them (Coenen, McAdam and Straub, 2008). An overview is found in Table 1, while Table 2 provides an overview of the standard deviation of shocks.

Parameter	Symbol	Value
Discount factor	β	0.990
Elasticity of demand in intermediate goods sector	ϵ	11.000
Taylor rule coefficient: inflation	ϕ_π	3.000
Taylor rule coefficient: output	ϕ_Y	0.250
Taylor rule coefficient: interest rate smoothing	μ	0.850
Feedback of adjustment account to spending	ρ	0.050
Fraction of firms that leave their price unchanged	θ_p	0.750
Share of liquidity constraint consumers	λ	0.330
Steady-state rate of employee wage taxes	$\bar{\tau}^d$	0.100
Steady-state rate of consumption taxes	$\bar{\tau}^C$	0.180
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
Relative weight of leisure to consumption	υ	1.000

Table 1: Baseline calibration

Shock type	Standard deviations
Consumer preferences	0.324
Technology	0.628
Price mark-up	0.140
Monetary policy	0.240
Government expenditure	0.331
Government revenue	0.329

Table 2: Standard deviations of shocks

3.2 Impulse response analysis

Given the above calibration, we start off by analyzing 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, to a price mark-up, and to technology. In section 4, we will draw welfare conclusions.

Shock to consumer preferences (CPS)

Figure 1 portrays the dynamic response of selected variables to a shock to consumer preferences if fiscal policy follows a DB.

Due to the additional demand posted to firms, firms that are allowed to reset prices increase these to cushion the increasing marginal cost pressure stemming from higher wages 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. As monetary authorities are determined to dampen inflation variability, they increase real interest rates and slow down 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 wipe out the positive impact of the consumer preference shock for Ricardian households from quarter three onward. 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 passed through to debt. Thus the DB embodies automatic stabilization on the revenue side as government expenditures are decoupled from cyclical movements in revenues and kept at trend. The mildly procyclical 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 2 depicts the business cycle dynamics if fiscal authorities are determined to balance

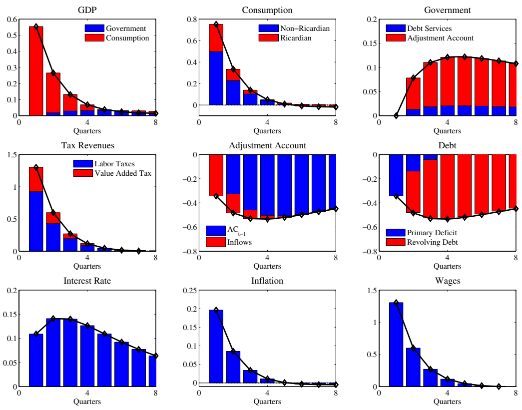

Figure 1: DB and CPS

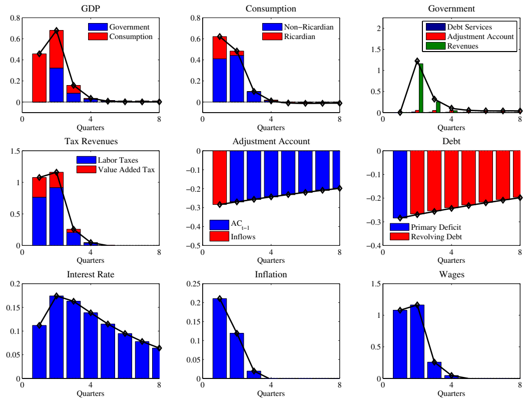

Figure 2: BB and CPS

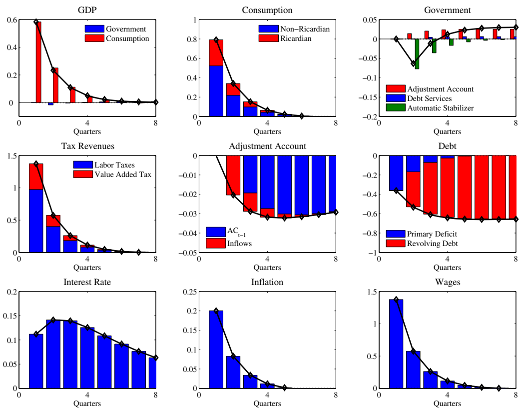

Figure 3: AS and CPS

the budget in each period. Due to the planning horizon of one period, the budget will not be 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 the driving component of GDP quantitatively, whereas for the DB, 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 DB, 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 from the partial adjustment account to expenditures gradually reduces the surpluses accumulated in the first period due to the expectations error.

Figure 3 illustrates the response to a consumer preference shock if the government tries to implement the AS rule. As for the case of a DB, the additional revenues are not spent but passed through to debt. Additionally, the higher countercyclical stance starts to take effect and diminishes government spending relative to the DB regime, which can be seen in the upper right panel. This implies that, in contrast to the DB regime, where the feedback from the adjustment account and debt services crowd out the countercyclical stance, a slightly countercyclical stance is present in the first three periods of the AS regime. As the government implements spending cuts in periods two and three, although revenue increases are high, surpluses accumulate faster than under the DB regime. Only afterwards, debt services and the adjustment account are strong enough to overcompensate the higher countercyclical stance. Besides this, the business cycle dynamics of the DB and the AS are very similar.

Shock to price mark-up (PMS)

Figure 4 illustrates the course of business cycle dynamics if the economy is hit by a persistent shock to the price mark-up. Those firms that can reset prices adjust them 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 the fiscal authorities implement a DB, 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 procyclically. This procyclical behavior stems from debt services and more moderate fiscal expenditure from quarter two onward as the government is com-

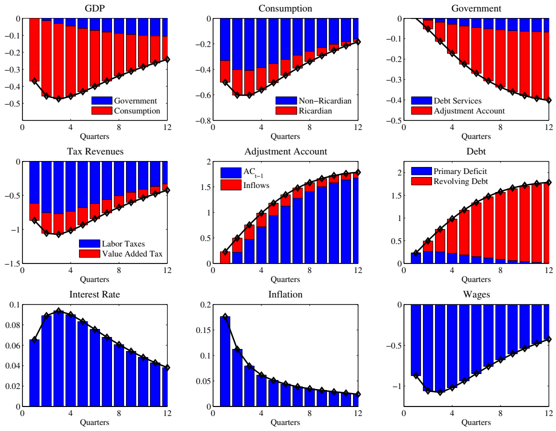

Figure 4: DB and PMS

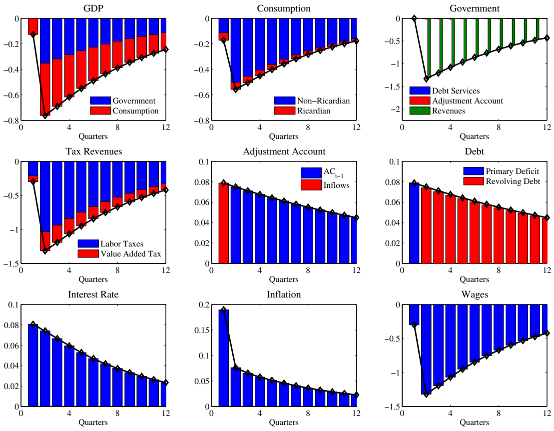

Figure 5: BB and PMS

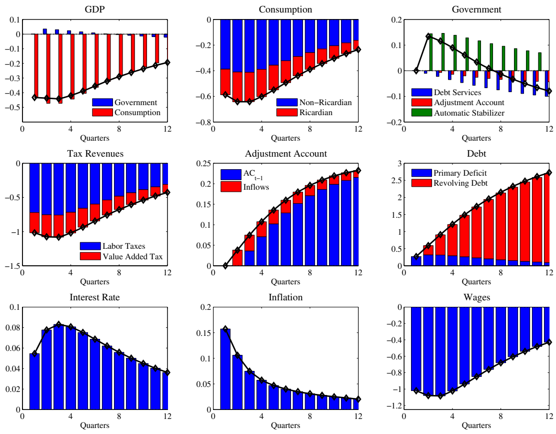

Figure 6: AS and PMS

mitted towards keeping the steady-state debt-to-GDP ratio constant over time. Therefore, the shortfall in revenues recorded on the adjustment account factors in cuts in government expenditures that gradually reduce debt to its steady-state level.

Figure 5 depicts the course of the economy if fiscal authorities are committed towards a BB. 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 at a more pronounced rate than under a DB regime. The fiscal contraction helps somewhat to relieve the economy from inflationary pressure such that the increase in real interest rates is more moderate than it would be if fiscal authorities kept the expenditure stream at trend.

Figure 6 portrays the dynamics of the business cycle if fiscal authorities implement AS. For the case of a price mark-up shock, this regime turns out to be the most passive in terms of fiscal expenditures because the countercyclical stance due to rule-based stabilization in output and the need to bring back real debt in the medium term almost cancel out each other. Hence, government expenditures are effectively kept constant. Consequently, fiscal authorities are less ambitious in their reversal of debt dynamics which prevail more persistently. This implies that the mildly countercyclical stance is only overcompensated by debt services and the feedback from the adjustment account from period eight onward.

Shock to technology (TS)

Figure 7 portrays the course of the business cycle dynamics if the economy is hit by a technology shock under a DB 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. The responses of this impulse portray that in the first quarter, fiscal balances deteriorate as labor tax revenues decrease while in later periods, additional value added tax receipts tend to improve the fiscal balance. 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 which can will 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, which then increases consumption of non-Ricardian households. The rise in consumption and output drive inflation back to its original level. Following the DB, the government basically keeps expenditures fixed to trend revenues and passes the fall in revenues through to debt, which, as in the other cases, leads to a very mild countercyclical movement of government spending to the evolution of debt.

In Figure 8, we see how the business cycle dynamics change when the government follows a BB. In the first two periods, revenues decrease as labor and consumption tax receipts

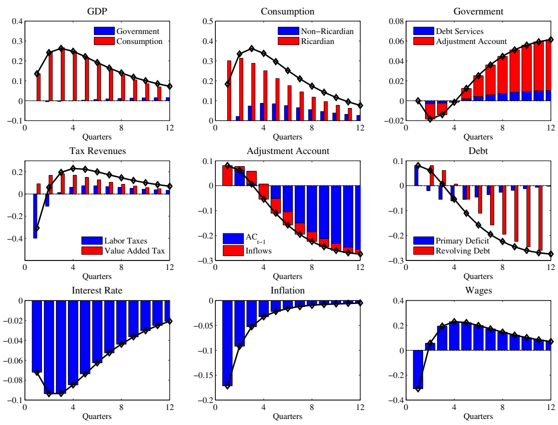

Figure 7: DB and TS

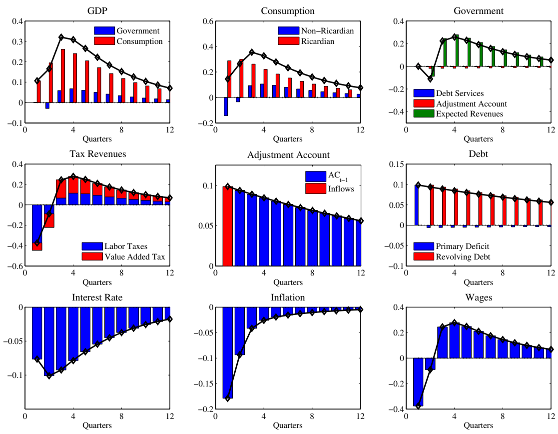

Figure 8: BB and TS

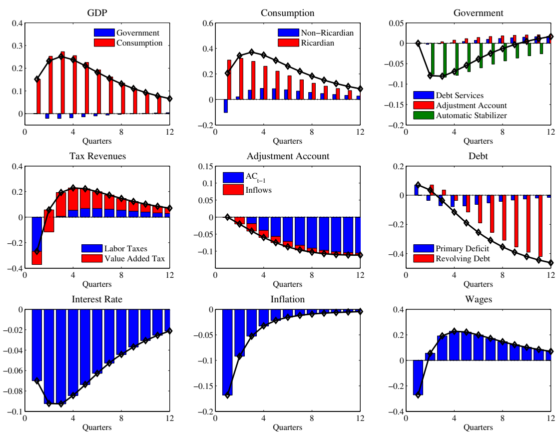

Figure 9: AS and TS

decline, which is not anticipated by the government and passed through to debt. However, in the third period, we see, in contrast to the DB regime, a sharp decrease in government expenditure due to the BB requirement. As inflation rates are below the central bank's inflation target, interest rate cuts encourage Ricardian households to increase consumption expenditures, which reverses the drop in GDP and leads to a sustained boom in output, such that labor tax revenues and value added taxes are above trend. Following a BB, the additional funds are spent, so fiscal authorities fuel the boom in output.

Figure 9 illustrates the business cycle dynamics under a AS regime. However, the countercyclical component in government expenditures builds in a negative correlation between GDP and government expenditures. From period three onward, the higher demand for goods and output makes firms raise wages to generate higher labor supply, which augments government revenue. These extra revenues are, basically, fully passed through to debt which falls at a stronger rate than in the case of the debt brake. Yet, government spending stays low as the countercyclical stance is not compensated by the reduced debt services and revenues on the adjustment account until period nine. Again, business cycle dynamics are similar to the DB regime.

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 (see also Erceg et al., 2000; Gali and Monacelli, 2008; and Woodford, 2003). The welfare function can be written as follows

$$\mathbb{W}_0 = E_0 \sum_{t=0}^{\infty} \beta^t U_t = \frac{(1-\upsilon\varphi)}{2} \sum_{t=0}^{\infty} \beta^t \left[(1+\hat{Y}_t)^2 - (\hat{Y}_t - \hat{\zeta}_t)^2 \right] - \upsilon\varphi \cdot \frac{\epsilon}{\kappa} \sum_{t=0}^{\infty} \beta^t \hat{\pi}_t^2. \quad (37)$$

Next, we characterize the welfare implications of the different fiscal policy regimes by means of numerical analysis for four types of shocks, namely shocks to consumer preferences, shocks to the price mark-up, transitory technology shocks and fiscal spending shocks. For the baseline calibration, more than 90% of the welfare losses are driven by these shocks. Therefore, we only discuss these four shocks in turn before presenting the overall welfare statistics.

Figures 10 to 13 portray the adjustment path of the annualized inflation rate in the upper panel (which dominates the welfare metric) for the different fiscal policy regimes under consideration. In the lower panel, the response of fiscal authorities under the different regimes is shown. As a reference point, we additionally report how a discretionary optimizing fiscal authority that responds to the predetermined state variables $\hat{\zeta}_t$, $\hat{\epsilon}_t$, $\hat{A}_t$, ν_t and b_{t+1} behaves by implementing the following rules

$$\hat{G}_t = -15.56_{(2.10)} \cdot \hat{\zeta}_{t-1} - 0.38_{(0.10)} \cdot b_t, \quad (38)$$

$$\hat{G}_t = -48.41_{(10.53)} \cdot \hat{\epsilon}_{t-1} - 0.36_{(0.11)} \cdot b_t \quad (39)$$

$$\hat{G}_t = 7.50_{(0.57)} \cdot \hat{A}_{t-1} - 0.33_{(0.05)} \cdot b_t \tag{40}$$

and

$$\hat{G}_t = -7.22_{(9.40)} \cdot \nu_{t-1} - 0.95_{(0.66)} \cdot b_t, \tag{41}$$

where the coefficients are chosen such that the welfare loss function, equation (37), is minimized. In order to give a fair comparison, we assume informational symmetry. This means that the optimizing fiscal policymaker can only react to the 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 2. *All proposed simple fiscal policy regimes perform significantly worse than an optimal discretionary fiscal policymaker that implements rules (38) to (41).*

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 as fiscal authorities succeed in favorably influencing wage dynamics and marginal costs by manipulating production plans and, thus, the spending behavior of non-Ricardian households. Accordingly, any policy measure which contributes to inflation stabilization increases welfare (see also the description of the business cycle dynamics in section 3.2).

Remark 3. *In particular, a BB moves government expenditures procyclically to inflation which aggravates the adverse welfare effects of price dispersion as it promotes a boom in overall consumption and provides a (relative) boost to inflation.*

In the presence of the BB, government spending, in principle, moves procyclically with inflation, whereas the optimal response would be to move in the exact opposite direction. An exception is the presence of a cost-push shock. In this case, as described in detail in Figure 5, tax revenues fall, which implies a fall in government spending when adapting the BB (while the other rules imply a rather fixed spending path, see Figure 11). Note, however, that this is the only type of shock in which the BB moves government spending in the right direction.

Remark 4. *The DB and the AS generally keep government spending stable and, thus, avoid being a source of economic disturbance. They are a lot better than the BB, namely* 10.0% *for the AS and* 7.2% *for the DB.*

As becomes clear by the description in section 3.2, government spending is kept more or less constant according to the DB and the AS. Hence, the inflation dynamics are quite similar. Inspection of Figure 10 shows that, for a consumer preference shock, inflation dynamics are, on impact, a little lower for the DB than for the AS, while the opposite holds for the cost-push shock.

Comparing the results for a cost-push shock, we observe that the AS fares better than the DB. This can be explained as follows: We observe in the first quarter that consumption

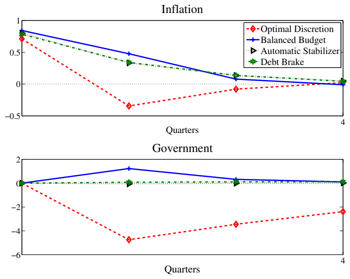

Figure 10: Preference shock and welfare

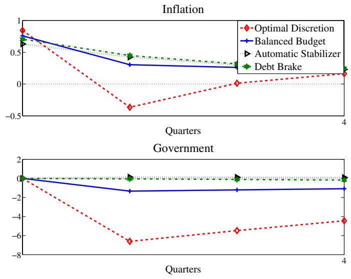

Figure 11: Cost-push shock and welfare

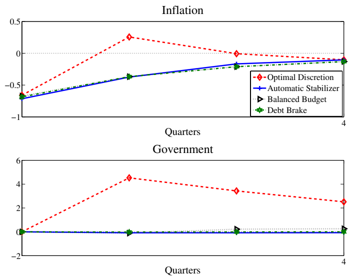

Figure 12: Technology shock and welfare

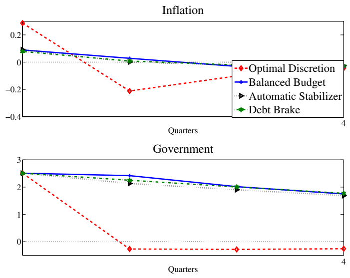

Figure 13: Fiscal shock and welfare

over both consumer types drops faster for the case of the AS. 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 DB regime.

The economic mechanism which drives the result for the DB is explained by the mild but highly persistent movement in government expenditures. 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 in 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, do 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, drives the differences in welfare results for a DB and an AS 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.

Is the evidence gained from Figures 10 to 13 robust? To discuss this issue, we conduct a simple robustness exercise. In precise terms, we compute the expected value of the loss function, equation (37), for the DB and for a BB and AS regime, respectively, and then take the ratio of the two. If the ratio takes a value one, then the loss under a DB 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 DB is smaller (larger) than the loss under the alternative fiscal policy regimes. The lines in Figure 14 indicate how the ratio changes for each of the four shocks when the share of non-Ricardian households is altered while the other parameters remain fixed at their baseline values.

The following results stand out. While the relative performance of the DB in comparison to the AS remains somewhat constant over a wide range of parameters, the relative performance of a BB hinges quite critically on the concrete parameter constellation. It prevails, in particular, that for an increasing share of non-Ricardian households, the BB regime fares poorly and ultimately fails to generate a determinate equilibrium. With an increasing share of non-Ricardian households, monetary authorities lose 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.

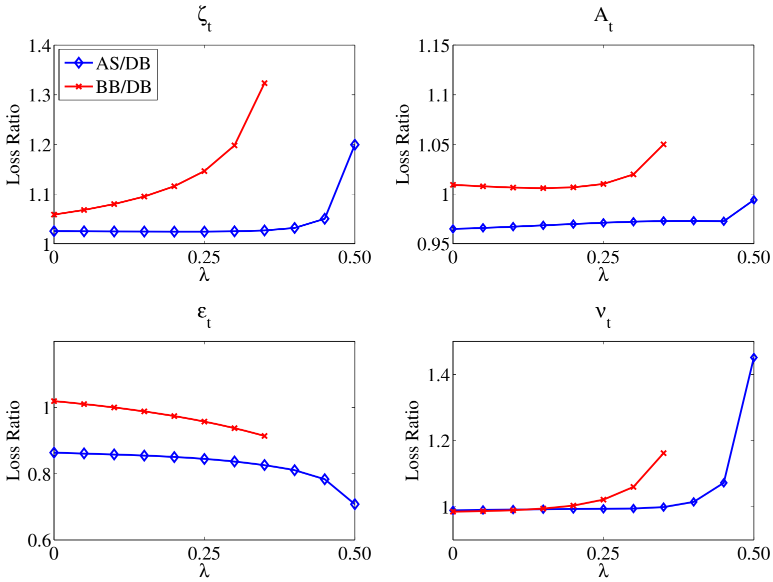

Figure 14: Robustness λ

5 Discussion and further research questions

The aim of this section is to address some relevant policy issues from the perspective of our model, caveats of the model and to point out important further research questions regarding fiscal policy rules in vein of a DB. The arguments made here can, on a more analytical basis, be retraced in Appendix A.

The first question that comes to mind is how strongly the balance of the adjustment account should feed back to government spending. In order to analyze this question within our model, it seems natural to minimize the welfare metric presented in equation (37) with respect to the feedback parameter ρ dependent on each shock. We find that the feedback should be rather small, around $\rho \approx 0.05$ as in our baseline-calibration, in order for fiscal policy not to create much fluctuation within the economy. Only for discretionary fiscal policy shocks, should the feedback be high and, thus, there should be a sharp correction of the earlier lapses because a positive government spending shock and a negative correction through the adjustment account cancel each other out relatively easily. Similar evidence is reported by Kremer and Stegarescu (2008), who report the optimal speed of adaption for German data.

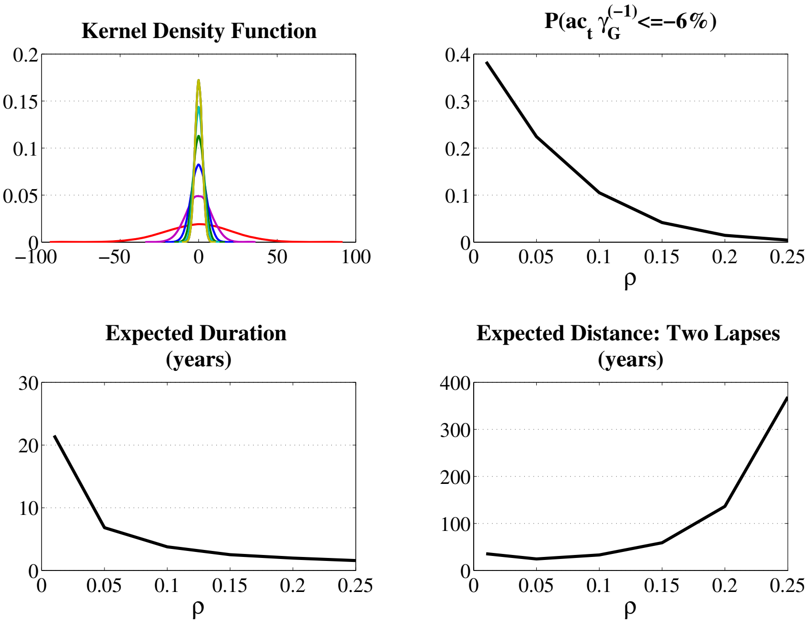

Figure 15: Adjustment account dynamics and feedback parameter

As a device to compare the proposed debt brake regime to the Swiss debt brake, we simulate the model over 500,000 quarters, where we draw the shocks from a multivariate normal distribution with standard deviations as reported in Table 2. As in Switzerland, we introduced a critical threshold of −6% of the adjustment account normalized by steady-state fiscal expenditures and computed relevant statistics.

In the upper panel, the figure illustrates that the shape of the kernel density function of the adjustment account is driven by the choice of the adjustment parameter. Given

Proposition 1, this does not come as a surprise as the distribution flattens with decreasing values of ρ and exhibits a near random walk behavior for $\rho = 0.01$.

The analysis of the simulation leads to the following findings. First, the unconditional probability that the adjustment account is below -6% decreases along a convex line with an increasing feedback parameter ρ and drops below 1% for $\rho = 0.25$. Second, if the adjustment account passes the threshold values of -6%, the unconditionally expected duration of consecutive violations of the threshold value decreases along a convex line with increasing values of ρ. For the baseline, the expected duration is well above six years. Third, violations of the threshold value are highly persistent if they occur, but are rare events. The expected duration between two lapses increases along a convex path for increasing values of ρ. For the baseline calibration, the expected distance between two lapses is 25 years. We conclude that by choosing ρ appropriately, the unconditional probability, expected duration as well as the distance between two violations is implicitly determined by the government.

Another issue inflicting immediately is the fact that in our model, trend output is known to all the agents within the model. This, of course, does not hold in practice and there is quite some evidence for estimation errors being an issue (see Brunez, 2003, Kremer and Stegarescu, 2008). Heinemann (2006) even suggests that politicians may have an incentive to misestimate. As a first and highly stylized approach to tackle this issue, we conduct the following experiment in our model. Let us assume that the government falls prey to estimation errors for 16 quarters in a row and that trend output is estimated to be one percentage point higher than it actually is. It is then evident that government spending tends to be too high, which cannot be neutralized by the feedback from the adjustment account. Furthermore, we assume that, from quarter 16 to 17, the government finally realizes that the trend has been incorrectly estimated and adjusts its expenditures accordingly. We then find three important points. 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 by setting up an adjustment account, it is possible to balance the desire to keep the debt bounded while, at the same time, not aggravating the economy at large, if fiscal authorities fall prey to measurement errors (see Appendix A.2). However, the simple example shows that this issue certainly merits further research.

6 Conclusion

In this paper, we analyze the effects of simple government spending rules which aim at stabilizing the economy in a sustainable way. We use a conventional New Keynesian DSGE model to implement the idea of a balanced budget rule (BB), a debt brake (DB) and a debt brake with higher countercyclical stance (AS). The DB, which is currently in action in Switzerland and soon to be implemented in Germany, is a rule tying government spending to real trend revenues. Cyclical surpluses/deficits and expenditures resulting from discretionary fiscal actions 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. The AS implies a higher countercyclical stance in government spending regarding output deviations, while also implementing the adjustment account just described. The BB demands balanced budgets each period, while the other two regimes only demand structurally balanced budgets.

We find that, not surprisingly, the BB does not stabilize the economy as it moves directly with (projected) government revenues. The DB and the AS have very similar business cycle effects. However, even though the DB and the AS rules are both constructed to generate countercyclical spending behavior, government spending in the DB regime is still moderately positively correlated with business cycle fluctuations in GDP, while government spending in the AS regime indeed has a mildly countercyclical stance regarding GDP. The weakening of the countercyclical stance in both regimes can be attributed to the interest payments on outstanding debt and the existence of an adjustment account, which serves to generate a constant level of debt in the long run. For the DB regime, this even overcompensates the countercyclical stance regarding the correlation of cyclical movements in government spending and GDP. In terms of welfare, calculated as an average consumer loss function, the DB and the AS are very similar and, generally, dominate the BB regime. Nevertheless, on an aggregate level, the AS seems to generate slightly smaller welfare losses of 2.8% compared to the DB for our baseline calibration. On a disaggregated level (i.e. analyzing each shock separately), the result also holds in principle. An exception is a cost-push shock, where the BB dominates the DB. The reason is that a cost-push shock yields higher inflation and lower tax revenue. Lower revenues imply less government spending and, thus, additionally lower aggregate demand and decrease the inflationary pressure under the BB. As inflation is the driving force of welfare losses in this class of models, the BB may be preferable – even though still contributing to more cyclical fluctuations – for a cost-push shock.

Overall, we find that all rules perform worse than optimal discretionary fiscal actions. However, we believe that the latter are not implementable due to reasons revealed in the political economic literature, but we have used them as a benchmark for comparison. Our general finding on an aggregate level is that a rule which steers fiscal expenditures along the trend path and abstains from activism is preferable as it at least prevents to fluctuations being actively introduced into the economy and, thus, acts as an automatic stabilizer.

Regarding the design of a simple fiscal spending rule, we can keep hold of the fact that, generally, attention should be devoted to the feedback of the adjustment account to real government spending, which shapes the distribution of the adjustment account. This feedback should be relatively strong for discretionary spending shocks only while adjustment of debt due to other economic shocks should die out more slowly. Additionally, it is important to take into account potential estimation errors, especially regarding trend output. Overestimating the trend generates too much government spending. We conclude that by setting up an adjustment account, it is possible to balance the desire to keep debt bounded, while not aggravating the economy at large, if fiscal authorities fall prey to measurement errors.

Appendix

A 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.

A.1 How to set the feedback of the adjustment account

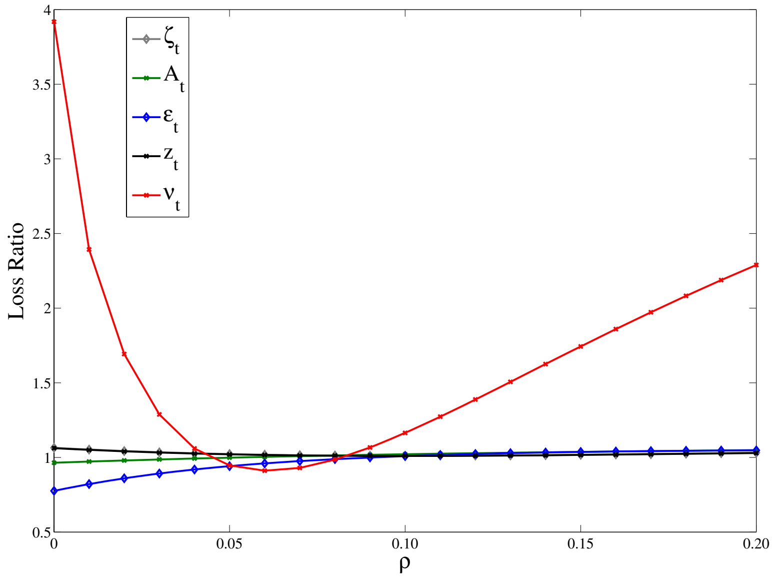

Figure 16: Optimal feedback coefficient for each shock

Figure 16 illustrates what would be the optimal response of the adjustment account from a welfare perspective if it was possible to fine-tune towards each specific shock. In precise terms, we computed the expected loss allowing ρ to vary from zero to one, while all other parameters are fixed at their baseline values and take the ratio to the baseline where we have fixed ρ at 0.05. While the statistic recommends a low feedback for technology and price mark-up shocks, it recommends a somewhat higher value for shocks to consumer preferences, monetary shocks and fiscal spending shocks.

A.2 Trend estimation errors

In this section, we extend 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; furthermore, there is quite a high frequency of trend revisions as time moves on.[8] 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 (21) and (22), we can express the debt brake in the presence of trend misestimation as

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

where $E_{t-1}\{a_t\}$ denotes an estimation error in trend output. Whenever it is greater than one, the 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 translates into

$$\hat{G}_t = \frac{(1-\beta^{-1})}{\gamma_G} b_t + \frac{\nu_t}{\bar{P}\bar{Y}} + E_{t-1}\{\hat{a}_t\} - \rho ac_{t-1} \tag{42}$$

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

$$ac_t = (1-\rho) ac_{t-1} + \frac{\nu_t}{\bar{P}\bar{Y}} + \gamma_G \left[E_{t-1}\{\hat{a}_t\} - \left(\hat{\Psi}_t - \hat{P}_t\right)\right]. \tag{43}$$

We see from equation (42) 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 clear to see that government spending will remain high for quite some time, even when the estimation error is corrected immediately in the next period as the adjustment account only partially feeds back on government spending. Because trend misestimations are usually correlated over time due to the available time series estimation methods, and it takes quite a while to realize that $E_{t-1}\{\hat{a}_t\} > 0$ is wrong, things may get even worse. As Brunez (2003) has shown, a bias in trend estimations cannot be neglected. Kremer and Stegarescu (2008) show with German data that the trend tends to be overestimated in booms and underestimated in downturns, while, on average, there seems to be an overestimation. Furthermore, there may also be a positive political economic bias as suggested by Heinemann (2006).

In Figure 17, 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 to be one percentage point higher than it actually is. Each period, the government

[8] In the words of Fritsche and Döpke (2006), "*it [may] not always [be] advisable to listen to the majority of forecasters*". The issue of trend misestimation 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 topic for further research.

is surprised to learn that output is lower than initially expected. Nevertheless, it attributes this to some source other than trend misestimation.

From quarter 16 to 17, the government then realizes that the trend was incorrectly 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.

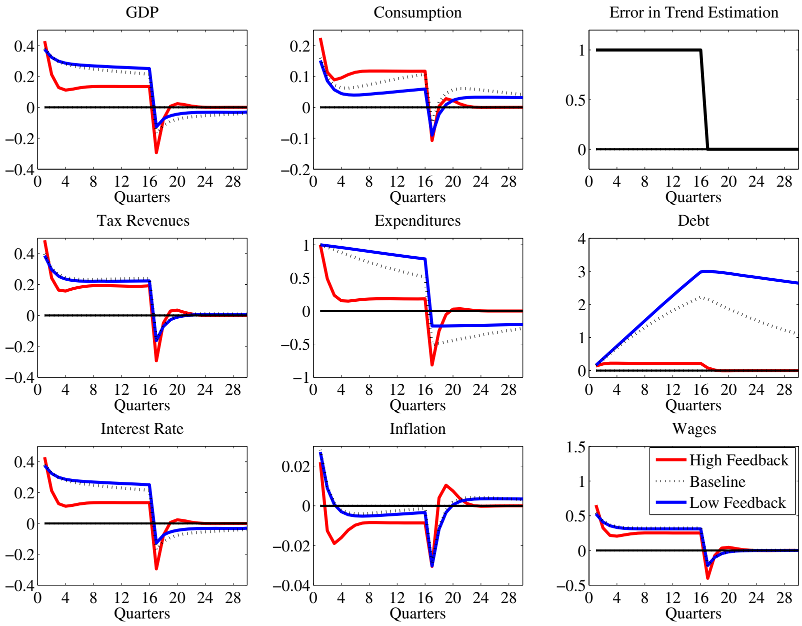

Figure 17: Trend estimation errors

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 by setting up an adjustment account, it is possible to balance the desire to keep the debt bounded while, at the same time, not aggravating the economy at large, if fiscal authorities fall prey to measurement errors.

B Firms' optimal price setting and the Phillips curve

Real marginal costs per firm can be represented by

$$mc_t(i) = \frac{W_t(1-\tau_n^s)N_t(j)}{P_t Q_t(j)} = \underbrace{A_t^{-1}}_{=N_t/Q_t} [(1+\tau^w)(1-\tau_n^s)w_t]. \tag{44}$$

Using equation (3), we can state real profits to be

$$\frac{\Pi_t(j)}{P_t} = \left[\frac{P_t(j)}{P_t} - mc_t(j)\right] Y_t(j). \tag{45}$$

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

$$E_t \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} \left[\frac{P_t(j)}{P_{t+k}} - mc_{t+k}(j)\right] Q_{t+k}(j), \tag{46}$$

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 (2), which is the isoelastic demand function. $\Lambda_{t,t+k}$ denotes the stochastic discount factor of shareholders (i.e. optimizing households), to whom profits are redeemed. It is defined as $\Lambda_{t,t+k} = (U_C^o(C_{t+k}^o)/U_C^o(C_t^o))$. β denotes a discount factor with $\beta \in (0,1)$. The corresponding Lagrangian is thus given by

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

where $\tilde{P}_t(i)$ is the optimal reset price and ϑ_t^j denotes the Lagrangian multiplier. The relevant first-order conditions of the firm's maximization problem are given by

$$\frac{\partial(.)}{\partial Q_t(j)} = \theta_p \beta \Lambda_t \left[\frac{\tilde{P}_t(j)}{P_{t+k}} - mc_{t+k}(j) - \vartheta_t^j\right] \equiv 0 \tag{47}$$

and

$$\frac{\partial(.)}{\partial \tilde{P}_t(j)} = E_t \left\{ \sum_{k=0}^{\infty} (\beta\theta_p)^k \Lambda_{t,t+k} \left[\frac{Q_{t+k}(j)}{P_{t+k}} - \vartheta_{t+k} \cdot \epsilon \left(\frac{\tilde{P}_t(i)}{P_{t+k}}\right)^{-\epsilon} \frac{P_{t+k}}{\tilde{P}_{t+k}(j)} \frac{1}{P_{t+k}} Y_{t+k}\right]\right\} \equiv 0. \tag{48}$$

Using equations (2) and (47) to substitute into equation (48), we get

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

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

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

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

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

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

$$\tilde{P}_t(j)=\frac{\epsilon}{\epsilon-1}\cdot\frac{E_t\left\{\sum_{k=0}^{\infty}(\beta\theta_p)^k\Lambda_{t,t+k}P_{t+k}^{\epsilon}Y_{t+k}mc_{t+k}(j)\right\}}{E_t\left\{\sum_{k=0}^{\infty}(\beta\theta_p)^k\Lambda_{t,t+k}P_{t+k}^{\epsilon-1}Y_{t+k}\right\}}\tag{49}$$

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

$$\tilde{P}_t(j)=\frac{\epsilon}{\epsilon-1}\cdot E_t\{mc_t^{flex}\cdot P_t^{flex}\}=P_t^{flex}.\tag{50}$$

Equation (50) 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 (49), 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 (49) 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

$$\hat{\hat{P}}_t(j) = (1-\beta\theta_p)\left\{\left(\hat{P}_t + \hat{mc}_t\right) + \beta\theta_p \hat{\hat{P}}_{t+1}(j)\right\}. \tag{51}$$

The aggregate 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, $\hat{P}_t^* = (1-\omega_p)\hat{\hat{P}}_t(j) + \omega_p \hat{P}_t^b$, 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

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

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)

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

Substituting the previous expression into equation (51) 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

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

which is equation (28). Note that in the main text, we will set $\omega_p = 0$.

C Aggregation of household sector

Households' FOCs: The first-order conditions for optimizing households are

$$\frac{\partial(.)}{\partial C_t^o(j)} = \frac{(1-\chi)\zeta_t}{C_t^o(j)} - \lambda_t^o(1+\tau_t^C) = 0, \tag{52}$$

$$\frac{\partial(.)}{\partial L_t^o(j)} = \frac{\upsilon\zeta_t}{L_t^o(j)} - \lambda_t^o(1-\tau_t^d)w_t = 0, \tag{53}$$

and

$$\frac{\partial(.)}{\partial B_{t+1}^o(j)} = -\frac{1}{P_t}\lambda_t^o + \beta E_t\left\{\lambda_{t+1}^o \frac{R_t}{P_{t+1}}\right\} = 0, \tag{54}$$

where λ_t^o is the Lagrangian multiplier associated with the budget constraint, equation (7). From equation (54), we know that

$$R_t^{-1} = \beta E_t\left\{\frac{\lambda_{1,t+1}^o}{\lambda_{1,t}^o}\frac{P_t}{P_{t+1}}\right\}, \tag{55}$$

which is the stochastic discount factor. Using equation (52) yields equations (8) and (9).

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

$$\frac{\partial(.)}{\partial C_t^r(j)} = \frac{(1-\chi)\zeta_t}{C_t^r(j)} - \lambda_t^r(1+\tau_t^C) = 0 \tag{56}$$

and

$$\frac{\partial(.)}{\partial L_t^r(j)} = \frac{\upsilon\zeta_t}{L_t^r(j)} - \lambda_t^r(1-\tau_t^d)w_t = 0, \tag{57}$$

where λ_t^r is the Lagrangian multiplier associated with the corresponding budget constraint. From equations (56) and (57), we derive equation (11).

Aggregate consumption Euler equation: The aim of the rest of this section is to derive an aggregate consumption Euler equation (in log-linearized terms) expressed only in aggregate 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. We know with the help of equation (12) that

$$N_t = \lambda N_t^r + (1-\lambda)N_t^o = \frac{\lambda\cdot(1-\chi)}{(1-\chi)+\upsilon_t} + (1-\lambda)N_t^o \tag{58}$$

and that

$$\begin{aligned} C_t &= \lambda C_t^r + (1-\lambda)C_t^o \\ &= \lambda\left[\frac{(1-\chi)}{\upsilon}w_t\frac{(1-\tau_t^d)}{(1+\tau_t^C)}L_t^r\right] + (1-\lambda)\left[\frac{(1-\chi)}{\upsilon}w_t\frac{(1-\tau_t^d)}{(1+\tau_t^C)}L_t^o\right] \\ &= \left[\frac{(1-\chi)}{\upsilon}w_t\frac{(1-\tau_t^d)}{(1+\tau_t^C)}\right]\underbrace{[\lambda L_t^r + (1-\lambda)L_t^o]}_{\equiv L_t}, \end{aligned} \tag{59}$$

where the index j has been dropped for notational convenience[9], while C_t^r is given by equation (11) and C_t^o by equation (9). Log-linearization of equation (59) yields

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

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 Frisch labor supply elasticity. Substituting $\hat{L}_t$ and rearranging thus gives

$$\hat{w}_t = \hat{C}_t + \varphi \hat{N}_t + \iota^d \hat{\tau}_t^d + \iota^C \hat{\tau}_t^C, \tag{60}$$

which is equation (30) of the main text.

We now come to some side-steps to be able to derive the aggregate consumption Euler equation. From equation (13) we know that, in steady state, $\bar{C}^r = \frac{(1-\bar{\tau}^d)(1-\chi)}{((1-\chi)+\upsilon)(1+\bar{\tau}^C)}\bar{w}$, while, from equation (59) 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

$$\frac{\bar{C}^r}{\bar{C}} = \frac{\upsilon}{1-\chi+\upsilon} \cdot \frac{1}{1-\bar{N}} \equiv \gamma_r, \tag{61}$$

where γ_r is, thus, the per capita consumption share of rule-of-thumb households relative to total per capita consumption. As we further know from equation (59) 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 (61) can be reformulated as

$$\frac{\bar{C}^o}{\bar{C}} = \frac{1}{1-\lambda} - \frac{\lambda}{1-\lambda} \underbrace{\frac{\upsilon}{1-\chi+\upsilon}\frac{1}{1-\bar{N}}}_{=\gamma_r} = \frac{1-\gamma_r\lambda}{1-\lambda} \equiv \gamma_o, \tag{62}$$

which, equivalently, gives the per capita consumption share of optimizing households relative to total per capita 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 (12), 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 (61). Thus,

$$\frac{\bar{L}^o}{\bar{L}} = \frac{1-\gamma_r\lambda}{1-\lambda} = \gamma_o \tag{63}$$

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

[9]Note that, due to state-contingent claims available for optimizing households, which are 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).

From equation (8), we know that, for the optimizing households, it holds that

$$\frac{\zeta_t}{C_t^o \cdot (1+\tau_t^C)} = \beta R_t E_t \left\{ \frac{\zeta_{t+1}}{C_{t+1}^o \cdot (1+\tau_{t+1}^C)} \cdot \frac{P_t}{P_{t+1}} \right\}. \tag{64}$$

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

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

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 (62) and (63))[10] as well as $\bar{r} = \beta^{-1}$. Substitution and rearranging yields

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

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

$$\hat{C}_t^o = E_t \hat{C}_{t+1}^o + \gamma_o \left\{ \iota^C E_t[\hat{\tau}_{t+1}^C - \hat{\tau}_t^C] + E_t[\hat{\zeta}_t - \hat{\zeta}_{t+1}] - \hat{r}_t \right\}. \tag{65}$$

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

$$\hat{N}_t^o = \frac{\hat{N}_t}{1-\lambda} \quad \Rightarrow \quad \hat{L}_t^o = -\frac{\varphi}{1-\lambda} \hat{N}_t \tag{66}$$

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 (13) and (59), it must hold that $\frac{C_t^r}{\bar{C}} = \frac{C_t}{\bar{C}} \frac{\upsilon}{(1-\chi)+\upsilon} \frac{1}{1-N_t}$, where a first-order Taylor expansion yields

$$\hat{C}_t^r = \gamma_r \hat{C}_t + \varphi \gamma_r \hat{N}_t, \tag{67}$$

where we have used the definition for γ_r (see equation (61)), $\varphi = \bar{N}/(1-\bar{N})$ and defined $\hat{C}_t^r = \frac{C_t^r - \bar{C}^r}{\bar{C}}$. Log-linearizing aggregate 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 (67) yields

$$\hat{C}_t^o = \underbrace{\frac{1-\gamma_r \lambda}{1-\lambda}}_{=\gamma_o} \hat{C}_t - \frac{\lambda \gamma_r \varphi}{1-\lambda} \hat{N}_t. \tag{68}$$

[10]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 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.

From equation (66), we know that $\Delta\hat{L}^o_{t+1} = -\frac{\varphi}{(1-\lambda)}\Delta\hat{N}_{t+1}$ must hold. Substituting this and equation (68) into equation (65) we get

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

where we have used $\hat{r}_t = [\hat{R}_t - \hat{\pi}_{t+1}]$, 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 (29). Equation (29) is the standard aggregate consumption Euler equation expressed in aggregate variables and deep parameters only. Individual steady-state relations have been substituted out but, of course, still drive equation (29) 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 (19) and (21), and the adjustment account, equations (20) and (22). From these equations, we see that, in steady state,

$$(\bar{R}-1)\bar{\tilde{b}} + \frac{\bar{G}}{\bar{Y}} = \frac{\bar{\Psi}}{\bar{P}\bar{Y}} - \rho\cdot\bar{ac} \tag{69}$$

and

$$\bar{ac} = (1-\rho)\bar{ac} + \frac{\bar{\Psi}}{\bar{P}\bar{Y}} - \frac{\bar{\Psi}}{\bar{P}\bar{Y}} \;\Rightarrow\; \rho\cdot\bar{ac} = 0. \tag{70}$$

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 (69), 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 (17) 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 (17) yields

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

where use has been made of equations (18) and (69) to derive the terms in the underbraces. Using the definition for any variable's deviation around its steady state as well as equation (69) and $\bar{R} = \beta^{-1}$, we can rearrange the above equation to $b_{t+1} + \left[\gamma_G - \bar{\tilde{b}}(1-\beta^{-1})\right]\left(\hat{\Psi}_t - \hat{P}_t\right) = \beta^{-1} b_t + \beta^{-1}\bar{\tilde{b}}\left(\hat{R}_{t-1} + \hat{P}_{t-1} - \hat{P}_t\right) + \gamma_G \hat{G}_t$.[11] Using the definition $\hat{\pi}_t \approx \hat{P}_t - \hat{P}_{t-1}$, rearranging yields equation (31).

A first-order Taylor expansion of the spending rule, equation (21), yields

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

whereas a first-order Taylor expansion of equation (19) yields

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

where we have already used the fact that $\bar{ac} = \bar{\nu} = 0$, the definition of equation (18) and the steady-state condition (69). Solving for $\hat{G}_t$, and combining the two previous equations yields equation (33).

A first-order Taylor expansion of equation (22) yields

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

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

while a first-order Taylor expansion of equation (20) is given by

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

which can be combined to equation (34).

E Steady-state considerations and social planner's solution

We know that, in the long run, equilibrium prices will be equal to the flex-price equilibrium. We know then that it holds that (see also equation (50))

$$\bar{mc} = \frac{\epsilon - 1}{\epsilon}, \tag{71}$$

where we have used $\tilde{P}_t(i) = P_t^{flex}$ which holds in the long-run steady-state. Additionally, we know from the cost minimization problem of a representative firm that (see equation (44))

$$\bar{w} = \bar{mc}\frac{\bar{Y}}{\bar{N}}\frac{1}{(1-\tau_n^s)}. \tag{72}$$

From equation (59), 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 (72) yields

$$\frac{(\epsilon-1)}{\epsilon}\frac{(1-\bar{\tau}^d)}{(1+\bar{\tau}^C)} = (1-\tau_n^s)\frac{\upsilon}{(1-\chi)}\frac{\bar{C}}{(1-\bar{N})}\frac{\bar{N}}{\bar{Y}}.$$

As we know that in an undistorted steady state without price mark-up, it must hold that $1 = \frac{\upsilon}{(1-\chi)}\frac{\bar{C}}{(1-\bar{N})}\frac{\bar{N}}{\bar{Y}}$, the following condition for the subsidy τ_n^s needs to hold in order to reach the undistorted steady state in our model set-up

$$\tau_n^s = 1 - \frac{(\epsilon-1)}{\epsilon}\frac{(1-\bar{\tau}^d)}{(1+\bar{\tau}^C)}. \tag{73}$$

With this subsidy at hand, it holds that

$$\frac{\bar{N}}{1-\bar{N}} = \frac{1}{\gamma_C}\frac{(1-\chi)}{\upsilon}, \tag{74}$$

where we have defined $\gamma_C = \frac{\bar{C}}{\bar{Y}}$. The solution for the steady-state labor supply is thus given by $\bar{N} = \frac{(1-\chi)}{\chi\gamma_C+(1-\chi)}$. 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 conditions resulting from equation (69), 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 (16))

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

where $\bar{\tau}^L = \bar{\tau}^w + \bar{\tau}^d$. Using equations (71) and (72), the definition $\gamma_C = \frac{\bar{C}}{\bar{Y}}$ and combining the last two equations yields

$$\gamma_G - (1-\beta^{-1})\bar{\bar{b}} = \bar{\tau}^L \frac{\epsilon-1}{\epsilon} \frac{1}{(1-\tau_n^s)} + \bar{\tau}^C \gamma_C. \tag{75}$$

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 (75), we then find that

$$\frac{\bar{G}}{\bar{Y}} = \gamma_G = \frac{1}{(1+\bar{\tau}^C)} \left\{ (1-\beta^{-1})\bar{\bar{b}} + \frac{\epsilon-1}{\epsilon} \bar{\tau}^L \frac{1}{(1-\tau_n^s)} + \bar{\tau}^C \right\} \tag{76}$$

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

$$\frac{\bar{C}}{\bar{Y}} \equiv \gamma_C = 1 - \gamma_G. \tag{77}$$

From the first-order condition of the cost minimizing problem of the firm, we know that $\bar{mc} = \frac{\bar{N}}{\bar{Y}} [(1-\tau_n^s)\bar{w}]$ (see equation (44)), where $\frac{\bar{N}}{\bar{Y}} = \frac{1}{\bar{A}} = 1$ as $\bar{A} = 1$ (see equation (4)), which, using equation (71) and rearranging yields

$$\bar{w} = \frac{1}{(1-\tau_n^s)} \frac{\epsilon-1}{\epsilon} = \frac{(1+\bar{\tau}^C)}{(1-\bar{\tau}^d)}, \tag{78}$$

where use has been made of equation (73). From equation (59) we can then calculate

$$\bar{C} = \frac{(1-\chi)}{\upsilon} \cdot \frac{1-\bar{\tau}^d}{1+\bar{\tau}^C} (1-\bar{N})\bar{w} = \frac{(1-\chi)}{\upsilon} \cdot (1-\bar{N}), \tag{79}$$

where $\bar{w}$ is given by equation (78) and $\bar{N}$ by equation (74). Using equation (79) and $\gamma_C = \frac{\bar{C}}{\bar{Y}}$, where γ_C is given by equation (77), we can calculate

$$\bar{Y} = \frac{\bar{C}}{\gamma_C}. \tag{80}$$

An analogous proceeding allows us – using equations (76) and (80) – to derive

$$\bar{G} = \gamma_G \bar{Y} = \bar{C} \frac{\gamma_G}{\gamma_C}. \tag{81}$$

Further, using equation (75), we know that

$$1 = \underbrace{\frac{\bar{\tau}^d(\epsilon-1)}{\epsilon(1-\tau_n^s)[\gamma_G-(1-\beta^{-1})\bar{\tilde{b}}]}}_{=Rev^L} + \underbrace{\frac{\bar{\tau}^C}{\gamma_C[\gamma_G-(1-\beta^{-1})\bar{\tilde{b}}]}}_{=Rev^{Vat}}, \tag{82}$$

where all parameters are known from the calculation above. This implies that we are able to express all aggregated variables in terms of exogenous parameters. Note that these aggregate 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 social planner's solution" (see also Gali and Monacelli, 2008, who apply exactly the same calculation procedure that is necessary here).

Social planner's solution: In the following, we will show that the competitive steady state equilibrium we just derived is identical to the solution of the social planner, if $\gamma_G = \chi$ (which we assume the social planner can choose). Therefore, in the following, we can claim to approximate around an efficient steady state. The optimal allocation of the model can be described by a social planner maximizing

$$\begin{aligned} SP_{Problem} &= \max\{\zeta_t\{\lambda[(1-\chi)log(C_t^r)+\chi log(G_t)+vlog(L_t^r)]\} \\ &\quad +(1-\lambda)[(1-\chi)log(C_t^o)+\chi log(G_t)+vlog(L_t^o)]\}\} \end{aligned} \tag{83}$$

with respect to C_t^r, C_t^o, L_t^r, L_t^o and G_t subject to the constraints $Y_t = C_t + G_t$ (market clearing), $Y_t = A_tN_t$ (technology constraint), $1 = N_t + L_t$ (labor constraint), where $L_t = \lambda L_t^r + (1-\lambda)L_t^o$ and $C_t = \lambda C_t^r + (1-\lambda)C_t^o$, which can be summarized in

$$A_t[1-(\lambda L_t^r+(1-\lambda)L_t^o)] = \lambda C_t^r + (1-\lambda)C_t^o + G_t. \tag{84}$$

The corresponding first-order conditions are given by

$$\frac{\partial(.)}{\partial C_t^r} = \zeta_t\lambda(1-\chi)\frac{1}{C_t^r} - \lambda\cdot o = 0,$$

$$\frac{\partial(.)}{\partial C_t^o} = \zeta_t(1-\lambda)(1-\chi)\frac{1}{C_t^o} - (1-\lambda)\cdot o = 0,$$

$$\frac{\partial(.)}{\partial L_t^r} = \zeta_t\lambda(1-\chi)\frac{1}{L_t^r} - \lambda\cdot o = 0,$$

$$\frac{\partial(.)}{\partial L_t^o} = \zeta_t(1-\lambda)(1-\chi)\frac{1}{L_t^o} - (1-\lambda)\cdot o = 0$$

and

$$\frac{\partial(.)}{\partial G_t} = \zeta_t\frac{\chi}{C_t^r} - \cdot o = 0,$$

where o is the corresponding Lagrangian parameter. Substituting it out, we find that

$$\frac{(1-\chi)}{C_t^r} = \frac{(1-\chi)}{C_t^o} = \frac{\upsilon}{A_t L_t^r} = \frac{\upsilon}{A_t L_t^o} = \frac{\chi}{G_t}, \tag{85}$$

which states that an efficient steady-state allocation implies that marginal utility of consumption across types of households and across alternative uses (public versus private goods) needs to be equal to the marginal utility of an additional unit of leisure across types. Using $L_t = (1 - N_t)$, we thus find that for an optimal steady state level of employment from a social planner's perspective, it holds that

$$\frac{\bar{Y}}{\bar{N}}\frac{(1-\chi)}{\bar{C}} = \frac{\upsilon}{(1-\bar{N})} \Rightarrow \frac{\bar{N}}{(1-\bar{N})} = \frac{1}{\gamma_C}\frac{(1-\chi)}{\upsilon},$$

which corresponds to equation (74) and, hence, is identical to the steady-state outcome in the competitive equilibrium with the labor subsidy at hand.

For the optimal distribution between public and private consumption goods, we make use of the fact that $\gamma_G = 1 - \gamma_C$ resulting from $\bar{Y} = \bar{C} + \bar{G}$, the market clearing condition. Using equation (85), this can be transformed to $\gamma_G = 1 - \frac{1}{\bar{Y}}\left[\lambda\bar{C}^r + (1-\lambda)\bar{C}^o\right]$, while we know from the first-order conditions of the social planner's problem that it must hold that $\bar{C}^r = \bar{C}^o = \frac{(1-\chi)}{\chi}\bar{G}$. Substituting in the previous equation, this implies $\gamma_G = 1 - \frac{\bar{G}}{\bar{Y}}\frac{(1-\chi)}{\chi} = 1 - \gamma_G\frac{(1-\chi)}{\chi}$, which yields $\chi = \gamma_G$. Using this, the optimal labor supply just calculated and the optimal consumption level from the first-order conditions, we find that

$$\bar{N} = \frac{1}{1+\upsilon}$$

and

$$\bar{C} = \frac{(1+\upsilon)}{(1-\gamma_G)}.$$

As shown above, this is equal to the solution obtained under the competitive equilibrium for $\chi = \gamma_G$ (see equations (74) and (79)), which implies that the competitive equilibrium is thus an efficient steady state.

F Welfare approximation

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

$$\left\{\underbrace{\zeta_t\left[(1-\chi)log\left(C_t^i(j)\right) + \chi log(G_t)\right]}_{=u^i} + \underbrace{\zeta_t\upsilon_t log\left(L_t^i(j)\right)}_{=V^i}\right\}, \tag{86}$$

where $i = o, r$ (see also equation (6)). 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

$$\begin{aligned}
u_t^i &\approx \bar{u}^i + \bar{u}^i_{C^i}\left(C_t^i - \bar{C}^i\right) + \frac{1}{2}\bar{u}^i_{C^iC^i}\left(C_t^i - \bar{C}^i\right)^2 + \bar{u}^i_G\left(G_t - \bar{G}\right) + \frac{1}{2}\bar{u}^i_{GG}\left(G_t - \bar{G}\right)^2 \\
&\quad + \bar{u}^i_{C^i\zeta}\left(C_t^i - \bar{C}^i\right)\left(\zeta_t - \bar{\zeta}\right) + \bar{u}^i_{G\zeta}\left(G_t - \bar{G}\right)\left(\zeta_t - \bar{\zeta}\right) \\
&= \bar{u}^i + (1-\chi)\frac{\left(C_t^i - \bar{C}^i\right)}{\bar{C}^i} - (1-\chi)\frac{1}{2}\frac{\left(C_t^i - \bar{C}^i\right)^2}{(\bar{C}^i)^2} + \chi\frac{\left(G_t - \bar{G}\right)}{\bar{G}} - \chi\frac{1}{2}\frac{\left(G_t - \bar{G}\right)^2}{\bar{G}^2} \\
&\quad + \frac{\left(\zeta_t - \bar{\zeta}\right)}{\bar{\zeta}}\left[(1+\chi)\frac{\left(C_t^i - \bar{C}^i\right)}{\bar{C}^i} + \chi\frac{\left(G_t - \bar{G}\right)}{\bar{G}}\right] \\
&= \bar{u}^i + (1+\hat{\zeta}_t)\left\{(1-\chi)\left[\frac{\hat{C}_t^i}{\gamma_i} - \frac{1}{2}\frac{(\hat{C}_t^i)^2}{\gamma_i^2} + \frac{1}{2}\frac{(\hat{C}_t^i)^2}{\gamma_i^2}\right] + \chi\left[\hat{G}_t - \frac{1}{2}(\hat{G}_t)^2 + \frac{1}{2}(\hat{G}_t)^2\right]\right\} \\
&= \bar{u}^i + (1+\hat{\zeta}_t)\left\{(1-\chi)\frac{\hat{C}_t^i}{\gamma_i} + \chi\hat{G}_t\right\},
\end{aligned} \tag{87}$$

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 (61) and (62), 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. Furthermore, we have neglected the individual household parameter j for notational convenience and remembered that $\bar{\zeta} = 1$. In an analogous proceeding as before, for the disutility of labor (utility of leisure) this yields

$$\begin{aligned}
V_t^i &\approx \bar{V}^i + \bar{V}^i_{L^i}\left(L_t^i - \bar{L}^i\right) + \frac{1}{2}\bar{V}^i_{L^iL^i}\left(L_t^i - \bar{L}^i\right)^2 + \bar{V}^i_{L^i\zeta}\left(L_t^i - \bar{L}^i\right)\left(\zeta_t - \bar{\zeta}\right) \\
&= \bar{V}^i + \upsilon\frac{\left(L_t^i - \bar{L}^i\right)}{\bar{L}^i} - \upsilon\frac{1}{2}\frac{\left(L_t^i - \bar{L}^i\right)^2}{(\bar{L}^i)^2} + \upsilon\frac{\left(L_t^i - \bar{L}^i\right)(\zeta_t - 1)}{\bar{L}^i} \\
&= \bar{V}^i + \upsilon\left\{\left[\frac{\hat{L}_t^i}{\gamma_i} - \frac{1}{2}\frac{(\hat{L}_t^i)^2}{\gamma_i^2} + \frac{1}{2}\frac{(\hat{L}_t^i)^2}{\gamma_i}\right]\right\} + \frac{\hat{L}_t^i}{\gamma_i}\left(\upsilon\hat{\zeta}_t\right) \\
&= \bar{V}^i + (1+\hat{\zeta}_t)\upsilon\frac{\hat{L}_t^i}{\gamma_i} = \bar{V}^i + (1+\hat{\zeta}_t)\upsilon\frac{\hat{L}_t^i}{\gamma_i}.
\end{aligned} \tag{88}$$

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

$$U_t^i(j) = \underbrace{\bar{u}^i(j) + \bar{V}^i(j)}_{\bar{U}^i} + (1+\hat{\zeta}_t)\left\{(1-\chi)\frac{\hat{C}_t^i(j)}{\gamma_i} + \chi\hat{G}_t\right\} + (1+\hat{\zeta}_t)\upsilon\frac{\hat{L}_t^i(j)}{\gamma_i}. \tag{89}$$

Noting that individuals of type r have a constant consumption pattern due to constant labor supply (see equations (12) and (13)), we know that $\hat{C}_t^r(j) = \hat{C}_t^r$, where the latter is given by equation (67). Due to the assumption of complete markets and state-contingent claims that can be purchased by households of type o, we know that $\hat{C}^o_t(j) = \hat{C}^o_t$ (see Woodford, 2003, chapter 2 for more details), where the latter is given by equation (68). 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 remainder, i.e. $(1-\lambda)$, is of type o, aggregate per-period utility can be expressed through the second-order Taylor approximation

$$\begin{aligned} U_t &= \underbrace{\lambda \bar{U}^r + (1-\lambda)\bar{U}^o}_{=\bar{U}} + (1+\hat{\zeta}_t)\left\{(1-\chi)\left[\lambda\frac{\hat{C}^r_t}{\gamma_r} + (1-\lambda)\frac{\hat{C}^o_t}{\gamma_o}\right] + \chi\hat{G}_t\right\} \\ &\quad + (1+\hat{\zeta}_t)\upsilon\left[\lambda\frac{\frac{1}{\lambda}\int_0^\lambda \hat{L}^r_t(j)dj}{\gamma_r} + (1-\lambda)\frac{\frac{1}{(1-\lambda)}\int_\lambda^1 \hat{L}^o_t(j)dj}{\gamma_o}\right] \end{aligned} \tag{90}$$

We can use the definition of the consumption aggregate and the labor aggregate, where it holds that

$$\hat{L}_t = \lambda\frac{1}{\gamma_r}\hat{L}^r_t + (1-\lambda)\frac{1}{\gamma_o}\hat{L}^o_t \;\; and \;\; \hat{C}_t = \lambda\frac{1}{\gamma_r}\hat{C}^r_t + (1-\lambda)\frac{1}{\gamma_o}\hat{C}^o_t,$$

where $\hat{L}^i_t$ and $\hat{C}^i_t$ denote the per capita log-deviations in the respective household segment. By definition, we know that $C^r_t = \frac{1}{\lambda}\int_0^\lambda C^r_t(j)dj$ and, henceforth, $\frac{1}{\gamma_r}\hat{C}^r_t = \frac{1}{\gamma_r}\frac{1}{\lambda}\int_0^\lambda \hat{C}^r_t(j)dj$. In complete analogy, we get $\frac{1}{\gamma_r}\hat{L}^r_t = \frac{1}{\gamma_r}\frac{1}{\lambda}\int_0^\lambda \hat{L}^r_t(j)dj$, $\frac{1}{\gamma_o}\hat{C}^o_t = \frac{1}{\gamma_o}\frac{1}{(1-\lambda)}\int_\lambda^1 \hat{C}^o_t(j)dj$ and $\frac{1}{\gamma_o}\hat{L}^o_t = \frac{1}{\gamma_o}\frac{1}{(1-\lambda)}\int_\lambda^1 \hat{L}^o_t(j)dj$. Substitution into equation (90) and rearranging gives

$$U_t = \bar{U} + (1+\hat{\zeta}_t)\left[(1-\chi)\hat{C}_t + \chi\hat{G}_t\right] - (1+\hat{\zeta}_t)\upsilon\varphi\hat{N}_t,$$

where we have substituted leisure for labor through $\hat{L}_t = -\frac{\bar{N}}{\bar{L}}\hat{N}_t = -\frac{\bar{N}}{1-\bar{N}}\hat{N}_t = -\varphi\hat{N}_t$. Further, we can use

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

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

$$U_t = \bar{U} + (1+\hat{\zeta}_t)\left[(1-\chi)\hat{C}_t + \chi\hat{G}_t\right] - (1+\hat{\zeta}_t)\upsilon\varphi\left[\hat{Y}_t - \hat{A}_t + \frac{\epsilon}{2}\sigma^2_t\right],$$

which can be simplified to

$$U_t = \bar{U} + (1+\hat{\zeta}_t)\left[(1-\chi)\hat{C}_t + \chi\hat{G}_t\right] - (1+\hat{\zeta}_t)\upsilon\varphi\hat{Y}_t - \upsilon\varphi\frac{\epsilon}{2}\sigma^2_t + o\left(||a^3||\right) + t.i.p., \tag{91}$$

where terms of order three (such as $\sigma_t^2 \zeta_t^2$) are collected in $o\left(||a^3||\right)$, while terms independent of policy (such as $(1+\hat{\zeta}_t)\upsilon\varphi\hat{A}_t$) have been put into $t.i.p.$. Using the income identity $\hat{Y}_t = \gamma_C \hat{C}_t + \gamma_G \hat{G}_t$ and the fact that $\chi = \gamma_G = (1-\gamma_C)$ in the efficient steady state, we get

$$U_t = \bar{U} + [1-\upsilon\varphi]\,(1+\hat{\zeta}_t)\hat{Y}_t - \upsilon\varphi\frac{\epsilon}{2}\sigma_t^2 + o\left(||a^3||\right) + t.i.p., \tag{92}$$

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

$$U_t = \frac{(1-\upsilon\varphi)}{2}\left[(1+\hat{Y}_t)^2 - (\hat{Y}_t - \hat{\zeta}_t)^2\right] - \upsilon\varphi\frac{\epsilon}{2}\sigma_t^2 + o\left(||a^3||\right) + \overline{t.i.p.}, \tag{93}$$

where

$$\overline{t.i.p.} = t.i.p. + \hat{\zeta}_t^2\frac{(1-\upsilon\varphi)}{2} - \frac{(1-\upsilon\varphi)}{2}$$

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 and neglecting al terms higher than second order, the discounted sum of utility streams can be written as equation (37).

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