

Fiscal Consolidations and Heterogeneous Expectations

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Abstract

We analyze fiscal consolidations using a New Keynesian model where agents have heterogeneous expectations and are uncertain about the composition of consolidations. We look at spending-based and tax-based consolidations and analyze their effects separately. We find that the effects of consolidations and the output multipliers are sensitive to heterogeneity in expectations before and after implementation of a specific fiscal plan. Depending on the beliefs about the type of consolidation prior to implementation, we show that heterogeneity in expectations may lead to optimism in the economy, improving thus the performance of a specific fiscal plan, or can work towards the opposite direction leading to pessimism, amplifying the contractionary effects of the consolidation. In general, we find that spending-based consolidations last longer and lead to deeper recessions when agents are boundedly rational compared to the rational expectations benchmark, while the opposite holds for tax-based consolidations.

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1 Introduction

The recent financial crisis gave rise to various types of government interventions. These interventions led to rising government debt levels in most advanced economies (see IMF (2011)). Consequently, the majority of governments of those economies started the implementation of consolidation policies. In the Eurozone, such policies are still pursued in an effort to overcome the debt crisis in the countries of the Periphery. This crisis reshaped the way governments, within and outside the Monetary Union, think in terms of fiscal policy. In particular, the necessity for fiscal sustainability has arisen. There is a vast empirical and theoretical literature focusing on fiscal consolidations (see Alesina and Ardagna (1998, 2010), Ardagna (2004), Alesina et al. (2015), Bertola and Drazen (1993), Bi et al. (2013) and Guajardo et al. (2014) among others). However, little attention has been paid to the analysis of fiscal consolidations when agents are boundedly rational and heterogeneous in the way they form expectations. In this paper, we build a framework that allows for these features and, given those, we provide further insights as regards the effects of fiscal consolidations in the economy.

Most of the theoretical literature on consolidations, so far, has assumed that agents are fully rational. The failure of traditional rational expectations models to capture some key facts in the data, especially after the recent financial crisis, raises the need for a richer modeling of economic behavior. In fact, the analysis of the effects of fiscal consolidations, in theoretical models, when agents are not behaving fully rational at all times and are heterogeneous has not been very extensive. In this paper, we contribute to this literature by building a closed economy New Keynesian model with distortionary taxes, where agents are boundedly rational and heterogeneous in the way they form expectations, in the spirit of Brock and Hommes (1997). Our target is to provide a framework where we can analyze the anticipation effects of fiscal consolidations, be it tax-based or spending-based, and how heterogeneity in expectations can alter the way a given type of consolidation affects the economy both ex-ante and ex-post. In fact, we show that heterogeneity in expectations and uncertainty regarding the type of the upcoming consolidation are crucial in determining the effectiveness of consolidations in stabilizing debt and its effects on economic activity, both before and after implementation.

We assume that there are two types of agents in the economy, namely, the Fundamentalists and the Naive agents. The first type uses announced policy (e.g. monetary and fiscal) rules when it forms its expectations about inflation and output. In particular, Fundamentalists take into account the commitment of the central bank to price stability. Moreover, when forming their expectations, they take into account the commitment of the fiscal authority to stabilize debt-to-GDP when the latter exceeds a certain threshold. On the contrary, Naive agents ignore the commitments of the

two authorities when forming their expectations, and use the last observations of economic variables as their forecast for the future. Notice that the Naive forecast would be optimal if inflation, output and other variables followed a random walk. The Naive forecast will therefore be nearly optimal when economic variables are highly persistent and can be described by a near unit root process. Agents can switch between the two forecasting types according to an endogenous fitness measure. Agents choose the type with the higher fitness measure (i.e. lower past forecast error). Moreover, we assume Euler equation learning (see Honkapohja et al. (2013)), so that both types of agents need to form one period ahead expectations only. We believe that the assumption that agents use simple, two period trade-offs like the Euler equation, better fits in our bounded rationality framework than the assumption that agents are able to form expectations over an infinite horizon, and are additionally able to choose a fully optimal consumption, labor or pricing plan up to the infinite future, given these expectations. An advantage of such an infinite horizon approach would be that it would be easier to model agents' responses to anticipated fiscal policy changes (as in e.g. Evans et al. (2009)). However, in our framework with heterogeneous agents, the presence of forward-looking fundamentalists allows us to model anticipation effects also under Euler equation learning. Furthermore, by assuming uncertainty about the exact timing of consolidators, we are also able to model consolidations that are anticipated already several periods before their implementation.

We assume that the government implements tax-based consolidations by raising a distortionary labor income tax. Spending-based consolidations are implemented through cuts in spending that is wasteful. Following Bi et al. (2013), we introduce uncertainty about the nature of fiscal consolidations. In particular, agents may be uncertain or wrong about whether the consolidation will be tax-based or spending-based and assign a probability to the occurrence of each type of consolidation. Given that the fiscal authority implements consolidations with a certain lag, this type of uncertainty affects expectations of Fundamentalists before consolidations are actually implemented. This is due to the assumption that those agents are forward looking and take into account the future monetary/fiscal policy stance.

We find that the anticipation of spending-based consolidations leads to an increase in output and that this can result in a wave of optimism in the economy in the spirit of De Grauwe (2012) and De Grauwe and Ji (2016), where naive agents keep expecting high output, and increase their consumption. On the other hand, the anticipation of upcoming tax-based consolidations can trigger a wave of pessimism. When consolidations are actually implemented however, spending cuts generally lead to deeper recessions than tax hikes, and to a slower decrease in the debt to GDP ratio. This is due to the bounded rationality of, and heterogeneity in, expectations, where especially naive

agents do not adjust their consumption in the way that fully rational agents would.

Tax-based consolidations are especially successful in reducing debt when Fundamentalists anticipated the consolidations to be spending-based. In this case the wave of optimism that is triggered by the expected spending-based consolidations is reinforced by the fact that more agents switch to Naive expectations, as Fundamentalists turn out to be wrong about the anticipated type of consolidation. In this case a considerable boom in output can persist even while the government is increasing taxes. Similarly, when spending-based consolidations were expected to be tax-based, they are less successful due to an increase in pessimism.

Finally, we find that optimism (pessimism) in the economy keeps rising when uncertainty about the timing of consolidations causes Fundamentalists to keep expecting spending-based (tax-based) consolidations during several periods before their implementation. This can then lead to a considerable decrease (increase) in the debt to GDP ratio before consolidations actually start.

Our findings contribute to the existing literature in several ways. To the best of our knowledge, this is the first study to analyze fiscal consolidations when agents are boundedly rational and switch to better performing heuristics over time.¹ We highlight the importance of anticipation effects, first, and, second, the degree of heterogeneity towards improving or deteriorating the performance of the consolidation, during and after implementation. We distinguish between the short and long-run effects of fiscal consolidations in terms of their performance in stabilizing debt. In line with the existing literature, we show that the magnitude, the duration, the composition and the likelihood of consolidation matter in determining the extent to which a specific type of consolidation is successful in stabilizing debt and/or is expansionary. Our major contribution, though, is that the assumption of boundedly rational agents leads to policy implications that may differ to those under rational expectations (RE) substantially. For instance, we show that heterogeneity in expectations generates pessimism in the economy after spending-based consolidations have been implemented. Contractions last longer than under RE and make consolidations to last longer as well. Under tax-based consolidations instead, pessimism after implementation evaporates more quickly. In this case, smaller tax hikes are needed compared to the RE case, and the consolidation lasts for less periods due to the quicker recovery in the tax base. We show that under RE, spending-based consolidations (anticipated and unanticipated) cause milder contractions on impact compared to

¹Erceg and Linde (2013) analyze fiscal consolidations in a currency union model with boundedly rational and heterogeneous agents. However, in their model a fixed fraction of agents consume all their income in every period and do not solve any inter-temporal optimization problem. In our model on the other hand, all agents solve an inter-temporal optimization problem given their expectations, and switch to a different expectation formation heuristic, if that heuristic has better past performance. Another distinctive feature of our model compared to theirs is the short-sightedness of Fundamentalists who are not fully rational and do not form expectations over the infinite future.

tax-based consolidations. However, in our behavioral model this result is reversed.

The next section provides a brief overview of the existing empirical and theoretical literature on fiscal consolidations. Section 3 outlines the model and the fiscal consolidations that may occur, as well as the heterogeneity in the way agents form expectations. Sections 4 and 5 analyze the performance of the two types of consolidations under different private sector expectations, by means of theoretical results and impulse responses, respectively. In Section 6 we discuss the intuition of the differences between spending- and tax- based consolidations in our behavioral model, and Section 7 concludes.

2 Related literature

In the literature, there is substantial research on the effects of fiscal consolidations. In particular, there has been much research on the effects of different types of fiscal consolidations (e.g. spending-based and tax-based). A large empirical literature provides evidence supporting the expansionary fiscal consolidations hypothesis (see Alesina and Perotti (1995), Perotti (1996), Alesina and Ardagna (1998, 2010), Ardagna (2004)). In particular, the key finding is that fiscal consolidations are sometimes correlated with rapid economic growth, especially when implemented by spending cuts rather than tax increases. On the other hand, another strand of the empirical literature using narrative data to identify consolidations, initially introduced by Romer and Romer (2010), finds that output drops following both types of consolidations and that recessions are deeper after tax hikes (Guajardo et al. (2014)).² Similarly, Alesina et al. (2015), using a richer structure for modeling fiscal consolidations which accounts for anticipation effects, find that spending-based consolidations are less costly, in terms of output losses than tax-based ones.³

Beetsma et al. (2015) analyze the confidence effects of fiscal consolidations, showing that consumer confidence deteriorates after revenue-based consolidation announcements in European countries.⁴ Our model captures this fact. When agents expect tax-based consolidations to be more likely

²Earlier papers using the conventional approach to identify fiscal consolidations argued in favor of the expansionary effects of spending-based consolidations ("expansionary fiscal austerity"), see Alesina and Ardagna (2010), Alesina et al. (2002), Alesina and Perotti (1996) and Giavazzi and Pagano (1990) among others. However, their measure of identifying consolidations (i.e. the CAPB) suffers from problems like reverse causality or changes in fiscal variables due to non-policy changes correlated with other developments in output. Finally, as Romer and Romer (2010) point out another approach, followed by Blanchard and Perotti (2002) using SVAR analysis and institutional information to identify consolidations, suffers from problems similar to those of the studies above.

³However, as Guajardo et al. (2014) argue, a drawback of contemporaneous estimates is that planned impacts on budgets may tend to be over-optimistic relative to the ex-post outcomes. Consequently, the negative effects of consolidations on output may be understated due to the induced bias. This is the case with spending cuts in many instances, where the announced cuts were stronger than those actually implemented (Beetsma et al. (2016)).

⁴Beetsma et al. talk about improvements in consumer confidence which translate into boosts in private consumption and ultimately in output and the opposite way when consumer confidence deteriorates.

to happen, output contracts even before implementation owing to pessimism due to the drop in expected future disposable income. On the other hand, Beetsma et al. (2015) find that spending-based consolidation announcements are less harmful in terms of consumer confidence before implementation. In our model, we show that output expands one period before implementation of anticipated spending-based consolidations, owing to the lower future real interest rates that Fundamentalists expect. Consequently, Naive agents become gradually more optimistic expecting higher output in the next period which we interpret as an improvement in confidence (or optimism) in the economy.

In the theoretical literature, Bertola and Drazen (1993) develop a model where the government satisfies its intertemporal budget constraint by periodically cutting spending, where the latter is inherently unsustainable. A worsening of the fiscal conditions can increase the probability of a beneficial fiscal consolidation which can thus be expansionary. Bi et al. (2013) augment the model of Bertola and Drazen (1993) with distortionary taxation and analyze the effects of different types of fiscal consolidations. Moreover, they look at the effects of persistence in those, as well as of the uncertainty of economic agents over the composition of the upcoming fiscal consolidation. Accounting for the monetary policy stance as well, they find that spending and tax-based consolidations can be equally successful in stabilizing government debt at low debt levels. Nevertheless, at high debt levels, spending-based consolidations are expected to be expansionary and more successful in stabilizing debt, especially when agents anticipate a tax-based consolidation. These though do not account for heterogeneity in expectations.

Finally, Erceg and Linde (2013) examine the effects of tax-based and spending-based consolidations in a two country DSGE model for a currency union. They assume agent heterogeneity by introducing fixed fractions of forward looking and "hand-to-mouth" households. They find that tax-based consolidations have less adverse output costs than spending-based ones in the short to medium-run. Moreover, they show that large spending-based consolidations can be counterproductive in the short-run when the zero lower bound in interest rate binds, while they argue in favor of a "mixed strategy" combining both types of consolidations.

Although little attention has been paid to heterogeneity in expectations, the effects of fiscal policy changes when agents are boundedly rational have been analyzed in the literature. Evans et al. (2009) look at the effects of fiscal policy changes in an infinite horizon adaptive learning model, where agents consider future policy changes as credible, and use steady state learning for future interest rates. In this case, forecasts under learning give rise to dynamics in interest rates that are different from the rational expectation dynamics. After a credible announcement of a change in fiscal policy in a specific moment in the future, interest rates under learning tend to fluctuate

many periods before implementation as opposed to the rational expectations case. In their approach though, when agents used Euler equation learning, they do not react to announced future policy changes (even one period before implementation). In our model instead, heterogeneity allows agents to react to announced future policy changes even with Euler equation learning. This is because of the existence of fundamentalists who trust the fiscal authorities and take into account the effect that the policy change will have on other variables one period before implementation.⁵

Mitra et al. (2013) using an RBC model where agents are fully aware of the imminent fiscal policy change but uncertain about the true law of motion of future wages and interest rates, show that systematic forecast errors can lead to periods of optimism and /or pessimism depending on the state of the economy. Specifically, optimism before implementation can lead to a gradual rise in private consumption and thereby output before and in some periods after implementation, due to the persistence in forecast errors. However, after implementation agents revise their forecasts downwards and this can lead to contractions and to periods of pessimism. Gasteiger and Zhang (2014) use a richer model with distortionary taxes and elastic labor supply and show that anticipated tax changes can lead to oscillatory dynamics due to waves of optimism or pessimism. Again, such waves arise from forecast errors. In our case pessimism or optimism arises for the same reason, but also depends on the degree of heterogeneity which is absent in the papers above. For instance, if Fundamentalists have been wrong about the type of the consolidation or about the path of inflation or output next period, they might switch to the naive rule which uses only past information. As the fraction of agents switching to that rule increases, pessimism or optimism in the economy also increases. This may either prolong expansions or contractions depending on the effects of the imminent consolidation in the periods prior to implementation.

3 The model

3.1 Households

In our model time is infinite and there is a continuum of households that differ only in the way they form expectations. In particular, a household can be either Naive or Fundamentalist. Households of the same type make identical decisions. The intra-temporal problem of each household i , consists of choosing consumption over a continuum of different goods to minimize expenditure. The elasticity

⁵Moreover, Evans et al. (2009) do not analyze fiscal consolidations but instead look at balanced budget changes in spending, while bonds are in zero net supply. They also consider lump-sum taxes abstracting thereby from the distortionary effects of taxation and its effects on agents expectations.

of substitution between the different goods is θ , so that households choose

$$C_t^i(j) = \left(\frac{p_t(j)}{P_t} \right)^{-\theta} C_t^i, \quad (1)$$

with C_t^i and P_t being total consumption of the household and the aggregate price level, respectively, defined by

$$C_t^i = \left(\int_0^1 C_t^i(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}, \quad (2)$$

$$P_t = \left(\int_0^1 P_t(j)^{1-\theta} dj \right)^{\frac{1}{1-\theta}}. \quad (3)$$

Household i chooses consumption (C_t^i), labor (H_t^i), and nominal bond holdings (B_t^i) to maximize

$$\tilde{E}_t^i \sum_{s=t}^{\infty} \beta^s \left[\frac{(C_s^i)^{1-\sigma}}{1-\sigma} - \frac{(H_s^i)^{1+\eta}}{1+\eta} \right], \quad (4)$$

subject to its budget constraint

$$P_t C_t^i + B_t^i \leq (1 - \tau_t) W_t H_t^i + (1 + i_{t-1}) B_{t-1}^i + P_t \int_0^1 \Xi_t(j) dj, \quad (5)$$

where W_t is the nominal wage, τ_t is the labor tax rate, and i_t is the nominal interest rate. $\Xi_t(j)$ represents firm j 's real profits while \tilde{E}_t^i is the type-specific expectation operator of household i (which can either be Naive or Fundamentalist).

Dividing the budget constraint by $P_t Y_t$ and writing bonds in real terms as a share of GDP $b_t^i = \frac{B_t^i}{P_t Y_t}$ gives

$$\frac{C_t^i}{Y_t} + b_t^i \leq (1 - \tau_t) w_t \frac{H_t^i}{Y_t} + \frac{(1 + i_{t-1}) b_{t-1}^i Y_{t-1}}{\Pi_t Y_t} + \frac{\Xi_t}{Y_t}, \quad (6)$$

where $\Xi_t = \int_0^1 \Xi_t(j) dj$ are aggregate real firm profits, $\Pi_t = \frac{P_t}{P_{t-1}}$ is the gross inflation rate, and $w_t = \frac{W_t}{P_t}$ is the real wage rate.

The first order conditions with respect to C_t^i , H_t^i and b_t^i lead to the usual Euler equation and to an expression for the real wage, which, together with the budget constraint (6), must hold in equilibrium:

$$(C_t^i)^{-\sigma} = \beta \tilde{E}_t^i \left[\frac{(1 + i_t)(C_{t+1}^i)^{-\sigma}}{\Pi_{t+1}} \right], \quad (7)$$

$$w_t = \frac{(H_t^i)^\eta (C_t^i)^\sigma}{(1 - \tau_t)}. \quad (8)$$

3.2 Firms

There is a continuum of monopolistically competitive firms, producing the final differentiated goods. Each firm is run by a household and follows the same heuristic i for prediction of future variables as the household it is run by. We assume Rotemberg pricing. Each monopolistic firm j faces a quadratic cost of adjusting nominal prices, which can be measured in terms of the final good, and is given by

$$\frac{\phi}{2} \left(\frac{P_t(j)}{P_{t-1}(j)} - 1 \right)^2 Y_t, \quad (9)$$

where ϕ measures the degree of nominal price rigidity. As stressed by Rotemberg (1982) the adjustment cost accounts for the negative effects of price changes on the customer-firm relationship and is increasing in the size of the price change and in the overall scale of economic activity. Each firm has a linear technology with labor as its only input

$$Y_t(j) = AH_t(j), \quad (10)$$

where A is an aggregate productivity which we assume to be constant.⁶ The problem for firm j is then

$$\max_{\{Y_t(j), P_t(j)\}_{t=0}^{\infty}} \tilde{E}_t^i \sum_{s=0}^{\infty} Q_{t,t+s}^j P_{t+s} \Xi_{t+s}(j), \quad (11)$$

subject to the demand for its product. In the expression above, the term $Q_{t,t+s}^j$ represents the stochastic discount factor of the household that runs firm j , while the term $P_t \Xi_t(j)$ denotes firm j 's nominal profits defined as

$$\begin{aligned} P_t \Xi_t(j) &= P_t(j) Y_t(j) - mc_t Y_t(j) P_t - \frac{\phi}{2} \left(\frac{P_t(j)}{P_{t-1}(j)} - 1 \right)^2 Y_t P_t \\ &= P_t(j)^{1-\theta} P_t^\theta Y_t - mc_t P_t(j)^{-\theta} P_t^{1+\theta} Y_t - \frac{\phi}{2} \left(\frac{P_t(j)}{P_{t-1}(j)} - 1 \right)^2 Y_t P_t. \end{aligned} \quad (12)$$

The first order condition of the maximization problem of the firm with respect to $P_t(j)$ is

$$\begin{aligned} (1 - \theta) Y_t(j) + \theta mc_t \frac{P_t}{P_t(j)} Y_t(j) - \phi \left(\frac{P_t}{P_{t-1}(j)} \right) (\Pi_t(j) - 1) Y_t \\ + \phi \tilde{E}_t^j \left[Q_{t,t+1}^j Y_{t+1} \frac{P_{t+1}}{P_t(j)} \Pi_{t+1}(j) (\Pi_{t+1}(j) - 1) \right] = 0, \end{aligned} \quad (13)$$

where $\Pi_t(j)$ is the (gross) price inflation of the good produced by firm j . mc_t denotes the marginal

⁶Since our focus is on the effects of fiscal consolidations following a drop in the debt threshold we decide to shut down all shocks in order to keep the analysis simple. However, our results hold when debt rises above an unchanged threshold due to shocks hitting the economy other than an unanticipated fall in the debt threshold.

cost of the firm and is equal to $mc_t = \frac{w_t}{A}$. Finally, multiplying (13) by $\frac{P_t(j)}{P_t Y_t}$ and plugging in the stochastic discount factor gives

$$\begin{aligned} & (\theta - 1) \frac{P_t(j) Y_t(j)}{P_t Y_t} + \phi \Pi_t(j) (\Pi_t(j) - 1) \\ & = \theta mc_t \frac{Y_t(j)}{Y_t} + \phi \beta \tilde{E}_t^j \left[\left(\frac{C_{t+1}^j}{C_t^j} \right)^{-\sigma} \frac{Y_{t+1}}{Y_t} \Pi_{t+1}(j) (\Pi_{t+1}(j) - 1) \right]. \end{aligned} \quad (14)$$

3.3 Government and market clearing

The government issues one period bonds and levies labor taxes (τ) to finance its spending (G_t). Its budget constraint is given by

$$B_t = P_t G_t - \tau_t W_t H_t + (1 + i_{t-1}) B_{t-1}, \quad (15)$$

with $H_t = \int H_t^i di$ and $B_t = \int B_t^i di$ aggregate labor and aggregate bond holdings, respectively.

Dividing by $Y_t P_t$ gives

$$b_t = g_t - \tau_t w_t \frac{H_t}{Y_t} + \frac{(1 + i_{t-1}) b_{t-1}}{\Pi_t} \frac{Y_{t-1}}{Y_t} = g_t - \tau_t mc_t + \frac{(1 + i_{t-1}) b_{t-1}}{\Pi_t} \frac{Y_{t-1}}{Y_t}, \quad (16)$$

where $b_t = \frac{B_t}{P_t Y_t}$ and $g_t = \frac{G_t}{Y_t}$ are the real debt to GDP ratio and government expenditure to GDP, respectively.

The government adjusts spending and taxes according to the following rules:

$$g_t = g_1 - \zeta \gamma_1 \max(0, b_{t-2} - DT_{t-2}), \quad (17)$$

and

$$\tau_t = \tau_1 + (1 - \zeta) \gamma_2 \max(0, b_{t-2} - DT_{t-2}). \quad (18)$$

where DT_t is the debt threshold set by the government. When the debt ratio is above this threshold the government uses spending and/or taxes to stabilize the debt ratio. The parameter ζ determines whether the government uses spending, taxes, or a mixture of both to stabilize debt. For expositional clarity, we will only consider the two extreme cases where either spending is the only instrument ($\zeta = 1$) or taxes are the only instrument to stabilize debt ($\zeta = 0$). When the debt ratio is below the threshold, spending and taxes are set equal to their steady state values (τ_1 and

g_1). This means that below the threshold the government is not stabilizing debt. It only does so as long as debt exceeds the threshold.⁷ The debt threshold is set by the government to make sure that it will always have fiscal space. That is, the government wants to prevent the debt to GDP ratio from rising to a level close to the fiscal limit of the economy. If the debt to GDP ratio is far from this fiscal limit the government is not worried about the debt to GDP ratio in the economy and does not respond to it with fiscal variables. When the debt to GDP ratio rises above the threshold, the government starts to get concerned about its fiscal space, and adjusts spending or taxes proportional to how far the debt ratio has risen above the threshold.

Note that taxes and spending respond with a two period lag to deviations of the debt ratio from its threshold. This captures two features of the model. First, variables are not observed contemporaneously, neither by the agents nor by the government. Secondly, we assume that the government needs one period to process and implement fiscal adjustments.⁸ As a robustness check, we present in Appendix C.3, what would happen without the implementation lag in our benchmark case of correctly anticipated consolidations.

The threshold (DT_t) may change over time for two reasons. First of all, the government's preference for its desired fiscal space may change for e.g. political reasons. It may therefore increase (lower) its threshold to start consolidations farther from (closer) to the economy's fiscal limit. Secondly, the economy's fiscal limit may change due to market pressures, and the government may adjust its threshold accordingly to keep the same amount of fiscal space. In this paper we do not model these market pressures nor the fiscal limit. Instead, we consider exogenous changes in the debt threshold as a trigger for consolidations, without specifying for what reason the government decides to change this threshold.

We consider both anticipated and unanticipated consolidations. We model anticipated consolidations as follows. We assume that the economy initially lies in a state slightly above the debt threshold where the government uses either spending or taxes to stabilize debt.⁹ Agents are fully

⁷Even though fiscal policy is active when the debt ratio lies below the threshold, fiscal policy will become passive once the threshold is crossed. This implies that under active monetary policy the debt ratio can temporarily enter an explosive path, but that it will be stabilized eventually. Therefore, the transversality condition will be satisfied, and the model will be globally stable under rational expectations (RE). In the literature on the monetary/fiscal policy mix, it has been shown that a RE model can be globally stable even though the economy might spend periods in which both policies are active. This is the case as long as agents are aware of the fact that an active monetary/passive fiscal policy regime exists and is the most recurrent one (see Bianchi and Ilut (2017), Bianchi (2012) and Davig et al. (2007) among others). In our model, this regime will occur endogenously because of a rising debt ratio when both policies are active.

⁸The implementation we assume is motivated by Alesina et al. (2016) who argue that fiscal plans consist of a sequence of actions, some of which are designed to be implemented in the future. Gasteiger and Zhang (2014) also refer to legislation and implementation lags in fiscal policy and they model the latter. Finally, Leeper (2009) discusses empirical evidence for anticipated fiscal policy (e.g. fiscal foresight), while Leeper et al. (2013) provide empirical evidence of it.

⁹This initial state corresponds to a high debt fixed point, specified in section 4.3, consistent with a higher threshold.

aware of the fiscal instrument used and of the structure of the feedback rule. At date t the government lowers the debt threshold and announces the new debt threshold to the public. At date $t + 1$ the government observes the realization of b_t and compares it to the new debt threshold, DT_t . If $b_t > DT_t$, the government cuts spending or increases taxes, as in (17) or (18), depending on the value of ζ . Given the structure of the feedback rules, the consolidation starts two periods after the drop in the debt threshold (i.e. $t + 2$), as long as $b_t > DT_t$. In our benchmark case of correctly anticipated consolidations, the instrument used to consolidate is the same as the one that was used initially before the drop in the debt threshold, i.e., the value of ζ does not change. The size of the consolidation is determined by the distance of b_t from the new debt threshold, DT_t , and the policy parameter γ_1 , in the case of spending-based, or γ_2 in the case of tax-based consolidations. Fundamentalists trust the government fully and adjust their expectations accordingly one period before implementation.

Unanticipated consolidations are triggered in the same way with the difference that the lowering of the debt threshold by the government is not announced to the public. As such, Fundamentalists do not anticipate a spending cut or a tax hike.

In addition to anticipated and unanticipated consolidations we also consider different scenarios regarding changes in, and uncertainty about, the composition of the consolidation. In particular, we will consider cases where the value of parameter ζ is suddenly changed by the government on the day that consolidations start. This will not be announced to the public, and hence come as a surprise to agents.

Our classification of the alternative forms of consolidations is similar to Alesina et al. (2016), adjusted though to the specifics of our model. Alesina et al. (2016) classify anticipated consolidations as measures written in the legislation whose implementation was different from subsequent years, or measures implemented in a given year but already announced in the years before implementation (i.e. part of legislation adopted in previous years). They do not model those using a debt threshold as we assume in our model. In our case, incorporating a political process would complicate the analysis a lot. However, an announced drop in the debt threshold two periods before implementation leads to anticipation effects similar to those that Alesina et al. have in mind. As regards unanticipated consolidations, Alesina et al. classify those as measures that were immediately implemented. In our case instead, we stick with our framework of anticipated consolidations, but assume that the drop in the debt threshold is not announced so that the imminent consolidation is not expected. Finally, Alesina et al. account also for fiscal plans revised along the way and they model modifications of announced measures as unexpected shifts in fiscal policy. Our modeling of composition uncertainty

is close to theirs. Specifically, in our case agents are aware of the drop in the debt threshold and think they know the fiscal instrument to be used two periods later. However, when the implementation day arrives the government changes the instrument used and this is a surprise to the agents. So, there are anticipation effects in the periods before implementation but about the wrong type of instrument.

The aggregate resource constraint of the economy is summarized as

$$Y_t = C_t + G_t + \frac{\phi}{2} \left(\frac{P_t}{P_{t-1}} - 1 \right)^2 Y_t = C_t + g_t Y_t + \frac{\phi}{2} \left(\frac{P_t}{P_{t-1}} - 1 \right)^2 Y_t. \quad (19)$$

3.4 Log-Linearization and Aggregation

We log-linearize the model around the zero inflation steady state.¹⁰ The Euler equation, (7), can be log-linearized to get¹¹

$$\hat{C}_t^i = \tilde{E}_t^i[\hat{C}_{t+1}^i] - \frac{1}{\sigma}(i_t - \tilde{E}_t^i[\pi_{t+1}]). \quad (20)$$

Since our agents are boundedly rational, they are not able to fully optimize over an infinite horizon, taking account of all model equations and expectations about all variable up to infinity. Instead we assume as in Branch and McGough (2009), that our boundedly rational agents use Euler equation learning (see Honkapohja et al. (2013)), implying that they use the marginal costs versus marginal benefits trade-off of the Euler equation (20) to make decisions given their budget constraint, and given their subjective forecasts of aggregate variables for the next period.

Log-linearizing households i 's budget constraint, (6), we can write

$$(1-\bar{g})\hat{C}_t^i = (1-\bar{g})\hat{Y}_t + \frac{\bar{b}}{\beta}(\hat{i}_{t-1} + \hat{Y}_{t-1} - \pi_t - \hat{Y}_t) - \frac{\theta-1}{\theta}\tilde{\tau}_t + \frac{1}{\theta}(\hat{\Xi}_t - \hat{Y}_t) + (1-\bar{\tau})\frac{\theta-1}{\theta}(\hat{w}_t + \hat{H}_t^i) + \frac{1}{\beta}\tilde{b}_{t-1}^i - \tilde{b}_t^i \quad (21)$$

Using the log-linearized labor, leisure trade-off $\eta\hat{H}_t^i = -\sigma\hat{C}_t^i - \frac{\tilde{\tau}_t}{1-\bar{\tau}} + \hat{w}_t$, we can write the above in terms of the consumption decision as a function of aggregate variables and the change in the consumer's bond holdings

¹⁰We specify the zero inflation steady state in Appendix A.1

¹¹In what follows, for all the variables normalized with respect to GDP (debt, government purchases, federal expenditure, tax revenues) \tilde{x}_t denotes a linear deviation ($\tilde{x}_t = X_t - \bar{X}$) from its steady state. Instead, for all other variables \hat{x}_t denotes a percentage deviation ($\hat{x}_t = \log(X_t/\bar{X})$) from its steady state. This distinction avoids having the percentage change of a percentage. As regards inflation, we denote the log-linearized gross inflation Π_t as π_t .

$$\hat{C}_t^i = \frac{1}{(1-\bar{g}) + (1-\bar{\tau})\frac{\theta-1}{\theta}\frac{\sigma}{\eta}} \left[\left((1-\bar{g}) + \frac{1}{\theta} - (1-\bar{\tau})\frac{\theta-1}{\theta} \right) \hat{Y}_t + \frac{\bar{b}}{\beta} (\hat{i}_{t-1} + \hat{Y}_{t-1} - \pi_t - \hat{Y}_t) \right. \\ \left. - (1 + \frac{1}{\eta})\frac{\theta-1}{\theta}\tilde{\tau}_t + \frac{1}{\theta}\hat{\Xi}_t + (1-\bar{\tau})(1 + \frac{1}{\eta})\frac{\theta-1}{\theta}\hat{w}_t + \frac{1}{\beta}\tilde{b}_{t-1}^i - \tilde{b}_t^i \right] \quad (22)$$

Aggregating this equation across households yields

$$\int \hat{C}_t^i di = \frac{1}{(1-\bar{g}) + (1-\bar{\tau})\frac{\theta-1}{\theta}\frac{\sigma}{\eta}} \left[\left((1-\bar{g}) + \frac{1}{\theta} - (1-\bar{\tau})\frac{\theta-1}{\theta} \right) \hat{Y}_t + \frac{\bar{b}}{\beta} (\hat{i}_{t-1} + \hat{Y}_{t-1} - \pi_t - \hat{Y}_t) \right. \\ \left. - (1 + \frac{1}{\eta})\frac{\theta-1}{\theta}\tilde{\tau}_t + \frac{1}{\theta}\hat{\Xi}_t + (1-\bar{\tau})(1 + \frac{1}{\eta})\frac{\theta-1}{\theta}\hat{w}_t + \frac{1}{\beta}\tilde{b}_{t-1} - \tilde{b}_t \right] \quad (23)$$

where we use that aggregate bond holdings must equal the sum (i.e. integral) of the bonds held by all individual households: $\int \tilde{b}_t^i di = \tilde{b}_t$.

Meanwhile, we can log-linearize the government budget constraint, Equation (16), to get

$$\tilde{b}_t - \frac{1}{\beta}\tilde{b}_{t-1} = \tilde{g}_t - \frac{\theta-1}{\theta}(\tilde{\tau}_t + \bar{\tau}\hat{m}c_t) + \frac{\bar{b}}{\beta}(\hat{i}_{t-1} - \pi_t - \hat{Y}_t + \hat{Y}_{t-1}), \quad (24)$$

with

$$\hat{m}c_t = (\sigma + \eta)\hat{Y}_t - \sigma\frac{\tilde{g}_t}{1-\bar{g}} + \frac{\tilde{\tau}_t}{1-\bar{\tau}} \quad (25)$$

We then substitute this dynamic change in government bonds that follows from the government budget constraint, Equation (24) (the supply of bonds), for the dynamic change in total government bonds held by all households (demand for bonds) in Equation (23). Making use of $\hat{w} = \hat{m}c$, and of the log-linearized equation for real aggregate firm profits, $\hat{\Xi}_t = \hat{Y}_t - (\theta-1)\hat{m}c_t$, Equation (23) then reduces to

$$\int \hat{C}(i)_t di = \frac{1}{(1-\bar{g}) + (1-\bar{\tau})\frac{\theta-1}{\theta}\frac{\sigma}{\eta}} \left[((1-\bar{g}) + (1-\bar{\tau})\frac{\theta-1}{\theta}\frac{\sigma}{\eta})(\hat{Y}_t - \frac{\tilde{g}_t}{1-\bar{g}}) \right] = \hat{Y}_t - \frac{\tilde{g}_t}{1-\bar{g}} \quad (26)$$

Iterating the Euler equation (Equation (20)) forward for each household and plugging in in Equation (26) results in

$$\hat{Y}_t - \frac{\tilde{g}_t}{1-\bar{g}} = \int \hat{C}(i)_\infty di - \frac{1}{\sigma}\bar{E}_t \sum_k (i_{t+k} - \pi_{t+k}) \quad (27)$$

Here \bar{E}_t is the aggregate expectation operator defined by $\bar{E}_t[X_{t+1}] = \int \tilde{E}_t^i[X_{t+1}]di = n_t^N \tilde{E}_t^N[X_{t+1}] + (1 - n_t^N) \tilde{E}_t^F[X_{t+1}]$, with n_t^N the fraction of Naive agents.

As in Branch and McGough (2009), we now assume that the law of iterated expectations holds at the aggregate level, so that $E_t^i E_{t+k}^j x_{t+k} = E_t^i x_{t+k}$. Under that assumption it is possible to write Equation (27) recursively as

$$\hat{Y}_t - \frac{\tilde{g}_t}{1 - \bar{g}} = \bar{E}_t \hat{Y}_{t+1} - \frac{\bar{E}_t \tilde{g}_{t+1}}{1 - \bar{g}} - \frac{1}{\sigma} (i_t - \bar{E}_t \pi_{t+1}) + \int \hat{C}(i)_\infty di - \bar{E} \int \hat{C}(i)_\infty di \quad (28)$$

Finally, again, as in Branch and McGough (2009), we assume that agents agree on terminal wealth and consumption of all agents, so that $\int \hat{C}(i)_\infty di - \bar{E} \int \hat{C}(i)_\infty di = 0$. We then obtain the aggregate IS equation

$$\hat{Y}_t = \bar{E}_t \hat{Y}_{t+1} - \frac{1}{\sigma} (i_t - \bar{E}_t \pi_{t+1}) + \frac{1}{1 - \bar{g}} (\tilde{g}_t - \bar{E}_t \tilde{g}_{t+1}) \quad (29)$$

Log-linearizing the optimal pricing equation (14) and combining it with the market clearing condition and the marginal cost equations in their log-linearized form we end up with the inflation equation

$$\pi_t = \beta \bar{E}_t[\pi_{t+1}] + \kappa(\sigma + \eta) \hat{Y}_t - \kappa \sigma \frac{\tilde{g}_t}{1 - \bar{g}} + \kappa \frac{\tilde{\tau}_t}{1 - \bar{\tau}}, \quad (30)$$

where $\kappa = \frac{\theta - 1}{\phi}$.

We assume the central bank targets only inflation and that the inflation target is zero (which is consistent with the assumption of a zero inflation steady state that was assumed in the log-linearization in the previous section). The log-linearized forward looking Taylor rule is given by

$$\hat{i}_t = \phi_\pi \bar{E} \pi_{t+1}. \quad (31)$$

Linearizing (17) and (18) gives

$$\tilde{g}_t = -\zeta \gamma_1 \max(0, \tilde{b}_{t-2} - \tilde{D}T_{t-2}), \quad (32)$$

$$\tilde{\tau}_t = (1 - \zeta) \gamma_2 \max(0, \tilde{b}_{t-2} - \tilde{D}T_{t-2}). \quad (33)$$

3.5 Expectations Formation

We assume private sector beliefs are formed by two heuristics: Fundamentalistic and Naive. Naive agents comprise a fraction n_t^N of the population and believe future inflation, output and government spending to be equal to their last observed values: $E_t^N \hat{Y}_{t+1} = \hat{Y}_{t-1}$, $E_t^N \pi_{t+1} = \pi_{t-1}$, $E_t^N \tilde{g}_{t+1} = \tilde{g}_{t-1}$. Their expectations about future taxes do not show up in the equations of our model, and also do not influence Naive agents' predictions about other variables. We therefore do not need to specify these expectations.

Fundamentalists comprise a fraction $1 - n_t^N$ of the population and know that future taxes and government spending will depend on the debt ratio. They therefore base their expectations about these variables on the debt ratio. However, because of surprise policy changes, Fundamentalists may be wrong, or uncertain, regarding the composition of consolidations (i.e. the value of ζ). In any period t , they believe government spending to be the fiscal instrument (i.e. $\zeta = 1$) with probability α_t . In line with the fiscal rule of the government, they therefore believe that government spending will be given by

$$E_t^F \tilde{g}_{t+1} = -\alpha_t \gamma_1 \max(0, \tilde{b}_{t-1} - \tilde{D}T_{t-1}). \quad (34)$$

Similarly, they expect taxes to be the fiscal instrument (i.e. $\zeta = 0$) with probability $1 - \alpha_t$. Fundamentalists therefore expect that taxes are given by:

$$E_t^F \tilde{\tau}_{t+1} = (1 - \alpha_t) \gamma_2 \max(0, \tilde{b}_{t-1} - \tilde{D}T_{t-1}). \quad (35)$$

After they have observed a period of consolidations, Fundamentalists update their value of α_t . Throughout the paper we will assume that ζ has a fixed value, up until the point an unexpected composition change is announced or implemented. Fundamentalists do not anticipate that such surprise policy changes might arise. For this reason, after observing a period of spending-based consolidations Fundamentalists update their belief to $\alpha_t = 1$, and after observing a period of tax-based consolidations they update their belief to $\alpha_t = 0$.

Fundamentalists furthermore take account of their expectations about next period taxes and government spending when they form expectations about the other variables (they do this simultaneously). Our boundedly rational Fundamentalists are however not sophisticated enough to calculate perfect foresight paths until infinity and to base their expectations on such calculations. Instead they use a relatively simple heuristic to approximate the values of variables in the next period. Un-

less very extreme consolidations occur, the debt ratio will be a highly persistent variable in our model. Furthermore, when the debt ratio remains unchanged, fiscal variables remain unchanged as well, implying that also inflation and output remain constant. Fundamentalists use these features of the model to form expectations about next periods inflation and output. Using the model equations of inflation and output, the nominal interest rate rule, and their expectations about fiscal variables, fundamentalists calculate the (perfect foresight) fixed point values of inflation and output that would arise if fiscal variables remained unchanged. As long as the debt ratio, and therefore government spending and taxes, do not change to much from period to period, this heuristic gives a good approximation for next periods inflation and output.

Fundamentalists know that there are agents in the model that form expectations in a different manner. However, they do not know how many such agents there are in a given period and they also do not know what values other agents will predict. They can therefore not take these other agents into account in their expectation formation process. Instead Fundamentalists expect the values that would occur if all agents made correct (perfect foresight) predictions. That said, Fundamentalists' expectations about inflation and output at date t about $t + 1$ are as follows:¹²

$$E_t^F \pi_{t+1} = 0, \quad (36)$$

$$E_t^F \hat{Y}_{t+1} = - \left(\frac{\sigma}{\eta + \sigma} \frac{1}{1 - \bar{g}} \alpha_t \gamma_1 + \frac{1}{\eta + \sigma} \frac{1}{1 - \bar{\tau}} (1 - \alpha_t) \gamma_2 \right) \max(0, \tilde{b}_{t-1} - \tilde{D}T_{t-1}). \quad (37)$$

Since Fundamentalists make a joint prediction about all variables, the fractions of agents following this heuristic must be based on the relative performance of all predictions. Since expectations about taxes do not influence agents' decisions directly, it should not be included in the fitness measure. Similarly, the fraction of Naive agents is also based on the performance of all predictions. The most natural fitness measure then would be

$$U_{t-1}^i = -(\tilde{g}_{t-1} - E_{t-2}^i \tilde{g}_{t-1})^2 - (\pi_{t-1} - E_{t-2}^i \pi_{t-1})^2 - (\hat{Y}_{t-1} - E_{t-2}^i \hat{Y}_{t-1})^2, \quad (38)$$

where $i = F, N$. Following the fitness measure above, the fraction of Naive agents evolves as in Brock and Hommes (1997), according to

$$n_t^N = \frac{e^{\omega U_{t-1}^N}}{e^{\omega U_{t-1}^N} + e^{\omega U_{t-1}^F}}, \quad (39)$$

¹²Full derivation of these expectations are shown in Appendix A.2.

with U_{t-1}^N and U_{t-1}^F given by (38) evaluated at the Naive predictions and Fundamentalistic predictions respectively. ω is the intensity of choice parameter that determines how sensitive agents are to past performance of heuristics and how fast they switch between heuristics.

Aggregate expectations about government spending, inflation and output are given by

$$\bar{E}_t \tilde{g}_{t+1} = n_t^N \tilde{g}_{t-1} - (1 - n_t^N) \alpha_t \gamma_1 \max(0, \tilde{b}_{t-1} - \tilde{D}T_{t-1}). \quad (40)$$

$$\bar{E}_t \pi_{t+1} = n_t^N \tilde{\pi}_{t-1}, \quad (41)$$

$$\bar{E}_t \hat{Y}_{t+1} = n_t^N \tilde{y}_{t-1} - (1 - n_t^N) \left(\frac{\sigma}{\eta + \sigma} \frac{1}{1 - \bar{g}} \alpha_t \gamma_1 + \frac{1}{\eta + \sigma} \frac{1}{1 - \bar{r}} (1 - \alpha_t) \gamma_2 \right) \max(0, \tilde{b}_{t-1} - \tilde{D}T_{t-1}). \quad (42)$$

Above we assumed that agents know the model equations and are able to calculate the fixed point values that would arise if all agents made the "correct" forecasts. This however does not mean that these theoretically correct forecasts are indeed good predictors of the future. Due to heterogeneity in expectations formation, the above fixed point will not necessarily be reached. Instead, it is possible that the presence of Naive predictors in combination with shocks to the economy causes completely different dynamics. Naive predictors may then perform better than Fundamentalists. This would cause more Fundamentalists to abandon their model, since this model turned out not to be good enough to make adequate predictions about the actual law of motion of the economy. The fraction of Naive agents would then increase and waves of optimism or pessimism could arise.

3.6 Complete model

Our piecewise linear model is now given by The IS and Phillips curve, (29) and (30); the equations governing expectations, (40), (41), (42), and (38) and (39); the monetary and fiscal policy equations, (31), (32) and (33); and the evolution of the debt ratio, (24). A detailed summary of the model equations governing expectations and output and inflation dynamics above and below the debt threshold is presented in Appendix A.3.

4 Consolidations

Suppose that the government lowers the debt threshold, or that a shock to the economy increases the debt ratio. Suppose furthermore that the debt ratio is above its threshold.¹³ The government will then start planning consolidations proportional to the magnitude of the shock to debt or the

¹³Either because debt was already above the threshold, or because the lowering of the threshold has resulted in debt being above the threshold.

debt threshold, either in the form of spending cuts, or in the form of tax increases. If the government announces that it has lowered the debt threshold, then, in the period before the consolidations are implemented, fundamentalists will incorporate the anticipated consolidations into their expectations. Alternatively, the same anticipated consolidations could arise if Fundamentalists observe that in the previous period, the debt to GDP ratio has suddenly increased.

Below, we analyze the dynamics that arise when the upcoming consolidation are anticipated, and how these dynamics depend on the type of consolidation (spending or tax-based), the strength of consolidations (γ_1 and γ_2), and agents' initial beliefs. The latter consists of the fraction of agents that are Naive (n_t^N) and the *initial* probability Fundamentalists place on consolidations being spending-based (which we call α^*).

More specifically, the following quantities are affected: the levels of variables in the period where Fundamentalists expect a consolidation, but where it is not yet implemented (Section 4.1); the levels of variables during the implementation of consolidations (Section 4.2); and finally, the existence and stability (largest eigenvalue) of a fixed point above the debt threshold, as well as the debt ratio corresponding to that fixed point (Section 4.3). The first two subsections thus study short run dynamics, while the latter studies medium to long run dynamics. Short run dynamics are affected by initial beliefs (n_t^N and α^*), while the effect of these initial conditions die out in the long run.

4.1 Effects of expected consolidations due to a shock to debt or the debt threshold

If, in period t , the debt to GDP ratio is suddenly considerably above the debt threshold (either because an increase in the former or a drop in the latter), then in period $t + 1$, consolidations are expected by Fundamentalists, but not yet implemented. The actual type of consolidation then does not matter yet, but instead dynamics are driven by the type of consolidation that Fundamentalists expect. Depending on what type Fundamentalists expect, a consolidation can lead to either an expansion or a contraction in output. Furthermore, if the expansion is large enough, expected consolidations lead to a reduction in debt. We formalize this result in Proposition 1.

Proposition 1. *Assume that in period t either an announcement of a lowering of the debt threshold is made, or a shock to the economy has increased the debt to GDP ratio, and that it holds that ($\tilde{b}_t > \tilde{D}T_t$). This shock to the debt threshold or to debt affects next period's output (and thereby also inflation and debt) through Fundamentalists' expectations about future government spending*

and future output. The effect of a debt or debt threshold shock on next period's output is given by

$$\frac{\partial \hat{Y}_{t+1}}{\partial (\bar{b}_t - \bar{DT}_t)} = (1 - n_{t+1}^N) \left(\frac{\eta}{\sigma + \eta} \alpha^* \frac{\gamma_1}{1 - \bar{g}} - \frac{1}{\sigma + \eta} \frac{1}{1 - \bar{\tau}} (1 - \alpha^*) \gamma_2 \right). \quad (43)$$

This implies that the effect of expected consolidations on output and inflation is positive, if and only if

$$\alpha^* > \frac{\gamma_2(1 - \bar{g})}{\gamma_1(1 - \bar{\tau})\eta + \gamma_2(1 - \bar{g})}. \quad (44)$$

When this condition does not hold and the expectations lead to a contraction, then expected consolidation results in an increase in debt. When Condition (44) holds, the expected consolidation leads to a reduction in debt if and only if the expansion in output is large enough, so that it satisfies

$$\frac{\partial \bar{Y}_{t+1}}{\partial (\bar{b}_t - \bar{DT}_t)} > \frac{1 - \beta}{\beta \left((\bar{\tau}(\sigma + \eta))^{\frac{\theta-1}{\theta}} + \frac{\bar{b}}{\beta} (1 + \kappa(\sigma + \eta)) \right)}. \quad (45)$$

Proof. In Appendix B.1.

It follows from Proposition 1 that it is desirable that agents mainly expect spending-based consolidations. The higher the probability Fundamentalists place on spending-based consolidations, the larger the expansion of output, and the lower the debt to GDP ratio in the period before the consolidation is actually implemented. Furthermore, as can be seen in equation (43), when Fundamentalists do mainly expect spending-based consolidations, the expansion in output and the reduction in the debt ratio are increasing in the fraction of Fundamentalists ($1 - n_{t+1}^N$).

4.2 Effects of implemented consolidations

If, after one period, debt still is above the debt threshold, the expectational effects analyzed above are still present two periods after the shock. However, additionally there now are direct effects of implemented consolidations on output, inflation and debt. Below we analyze the total effects (including both the expectational and direct effects) of consolidations in the period that they are implemented for the first time, i.e., two periods after the shock. Proposition 2 states that in this period, a tax-based consolidation is always more effective than a spending-based consolidation.

Proposition 2. *For tax-based and spending-based consolidations of equal direct impact on the governments budget deficit ($\gamma_1 = \frac{\theta-1}{\theta} \gamma_2$), a tax-based consolidation always results in lower debt than a spending-based consolidation in the first period of implementation. Moreover, the difference in the*

impact on debt ($\frac{\partial \bar{b}_{t+2}}{\partial (\bar{b}_t - \bar{D}T_t)}$) between spending-based and tax-based consolidations is given by

$$\gamma_1 \left(\left(\bar{\tau} \frac{\theta - 1}{\theta} + \frac{\bar{\tau} \frac{\theta - 1}{\theta} - \bar{g}}{1 - \beta} \kappa \right) \left(\frac{\theta}{(\theta - 1)(1 - \bar{\tau})} + \frac{\eta}{1 - \bar{g}} \right) + \frac{\bar{\tau} \frac{\theta - 1}{\theta} - \bar{g}}{1 - \beta} \frac{1}{1 - \bar{g}} \right) \quad (46)$$

Proof. In Appendix B.2.

Expression (46) is always positive, so that, in the period where it is implemented for the first time, the debt ratio falls faster following a tax-based consolidation than a spending-based one. Moreover, it can immediately be seen that the difference in the debt ratio is increasing in the magnitude of consolidations (γ_1). Note furthermore, that the difference in reducing debt under the two types of consolidations does not depend on initial expectations (n_t^N and a^*). The reason for this is that these expectations affect the evolution of variables in the economy equally under both types of *implemented* consolidations.

4.3 Medium and long run dynamics

Above we explicitly analyzed the levels of variables in the first two periods after the debt or debt threshold shock. This gives clear insights in the short run dynamics that result from such a shock. Medium to long run dynamics will be determined by the existence and stability of a fixed point in the high debt region of the model. In this section, we investigate under what conditions this fixed point exists and how its stability is affected by the strength of consolidation, γ_1 and γ_2 . One period after the first implementation of consolidations, Fundamentalists have learned the type of consolidation and update their belief to $\alpha_t = 1$ or to $\alpha_t = 0$. For long run dynamics the value of α^* (their initial belief) therefore does not matter. Furthermore, the initial fraction of Naive agents (n_t^N) does not matter either for long run dynamics, because in a fixed point both types of agents will perform equally well, and the fractions will converge to 0.5 each.

4.3.1 Existence high debt fixed point

Proposition 3 states the condition for a fixed point with high debt to exist, in case of spending-based consolidations.

Proposition 3. *When consolidations are spending-based, a fixed point above the debt threshold exists if and only if*

$$\gamma_1 > \frac{1}{\beta} - 1. \quad (47)$$

Proof. In Appendix B.3.

Proposition 4 states that in case of tax-based consolidations, the condition for existence of the high debt fixed point is the same as in case of spending-based consolidations, but with γ_1 replaced by $\gamma_2 \frac{\theta-1}{\theta}$. This is intuitive because if we let $\gamma_1 = \gamma_2 \frac{\theta-1}{\theta}$, tax-based and spending-based consolidation are of equal magnitude in their effect on the budget deficit.

Proposition 4. *When consolidations are tax-based, a fixed point above the debt threshold exist if and only if*

$$\gamma_2 \frac{\theta - 1}{\theta} > \frac{1}{\beta} - 1. \quad (48)$$

Proof. In Appendix B.4.

We can conclude from Propositions 3 and 4 that when consolidations are strong enough (making fiscal policy "passive" above the debt threshold in the terminology of Leeper, 1991), an extra fixed point exists above the debt threshold, in addition to the fixed point below the debt threshold where all variables are at the steady state levels of Appendix A.1.

4.3.2 Stability of the high debt fixed point

When the fixed point above the debt threshold exists, dynamics in this region of the model are determined by the stability properties of the fixed point. When it is locally stable, convergence to the fixed point may occur, while otherwise debt will move away from the fixed point. Both convergence and divergence can happen monotonically or in an oscillatory fashion, depending on whether the eigenvalues are real and positive, or complex/negative. In order to get insight in dynamics when the debt ratio is above the threshold, we calculate the eigenvalues in the fixed point numerically. For this, we need to calibrate the model. Unless otherwise stated, we use the parameter values given in Table 1.

Parameter	Name	Value
β	Discount factor	0.99
σ	Relative risk aversion	2
$\frac{1}{\eta}$	Frisch elasticity of labor supply	0.5
θ	Elasticity of substitution	6
ϕ_π	Coefficient on inflation in Taylor rule	1.5
ω	Intensity of choice	10,000
ϕ	Price adjustment costs	100
\bar{g}	Steady state government spending	0.21
$\bar{\tau}$	Steady state taxes	0.26
\bar{b}	Steady state debt	0.66
DT_t	Deviation of debt threshold from steady state	0.14

Table 1: Parameter values

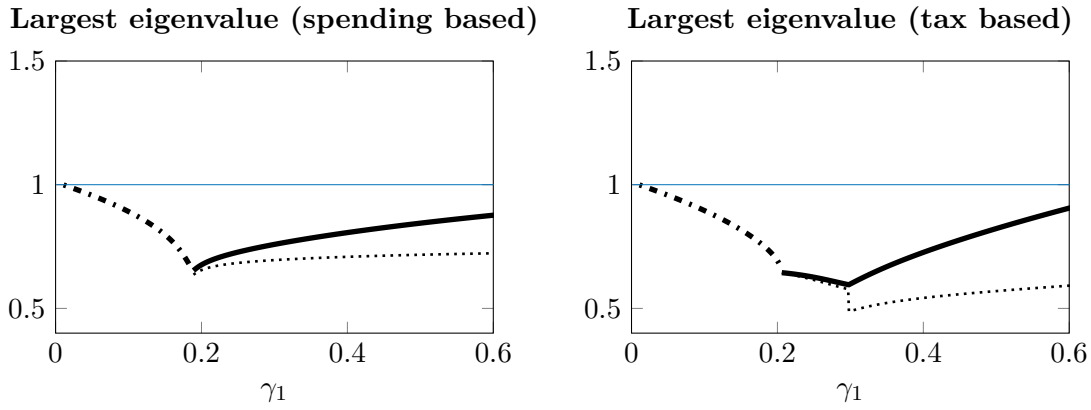


Figure 1: Absolute values of largest eigenvalue in high debt fixed point for spending and tax-based consolidations. The dashed-dotted segment depicts a real and positive eigenvalue, while a solid segment depicts complex eigenvalues. The real part of the complex eigenvalues is plotted as a dotted curve. In case of tax-based consolidations it holds that $\gamma_2 = \frac{\theta}{\theta-1}\gamma_1$.

In Figure 1 the absolute value of the largest eigenvalues in the high debt fixed point for spending-based (left panel) and tax-based (right panel) are plotted as a function of $\gamma_1 = \frac{\theta-1}{\theta}\gamma_2$ (the strength of consolidations). In the dashed-dotted part of the curves, the largest eigenvalue is real and positive. From the previous section we know that for very low values of γ_1 and γ_2 , the fixed point above the debt threshold does not exist. For this reason we do not plot the largest eigenvalue for $\gamma_1 < \frac{1}{\beta} - 1$. It can be seen in Figure 1, that under both types of consolidations the largest eigenvalue is real and equal to unity for the lowest allowed value of γ_1 . As γ_1 (and γ_2) go up, this real eigenvalue decreases and the fixed point becomes more and more stable, implying faster monotonic convergence to the fixed point. Around $\gamma_1 = 0.2$ the eigenvalues are quite low in absolute value under both spending-based and tax-based consolidations.

In the solid part of the eigenvalue curves, the largest eigenvalues (in absolute value) are complex. Here, the dotted line depicts the real part of these largest eigenvalues. When eigenvalues are complex, cyclical dynamics arise. This implies for our model that when the debt ratio is above the debt threshold, it will first decrease towards the fixed point, and then overshoot this debt ratio level and possibly also the debt threshold. When this happens, consolidations have been successful and no further spending cuts or tax increases are necessary up until the point that the debt ratio increases above the debt threshold again.¹⁴

In Appendix C.1 we show that the qualitative results from Figure 1 are robust to the specification of monetary policy, and to the parameterization of price adjustment costs (ϕ) and relative risk aversion (σ).

¹⁴The time it takes before the debt ratio increases above the threshold again does not depend on the dynamical system analyzed in this section. Instead, it depends on the system in case 1 of Appendix A.3. Here fiscal policy is active (taxes and spending do not respond to debt) and debt will always monotonically increase as long as $\tilde{b}_t > 0$.

4.3.3 Debt ratio in the high debt fixed point

When the high debt fixed point is stable, the level of the debt ratio in this fixed point is of crucial importance. When this debt ratio lies very close to the debt threshold, the government might be content with convergence to the fixed point. However, if the debt ratio lies considerably above the threshold, convergence to the fixed point is not desirable.

From the proofs of Proposition 3 and 4 it follows that, when the high debt fixed point exists and is stable, a more aggressive policy (higher γ_1, γ_2) leads to a lower debt ratio in the fixed point. Combining this with the results of the previous section, we can conclude that the government should respond strongly enough to debt. If it responds too weakly, slow monotonic convergence to a debt ratio significantly above the government's threshold will occur.

5 Impulse responses to a debt threshold shock

In this section we analyze the effects of a one time permanent drop to the debt threshold, both in the short run and in the long run, by means of simulated impulse responses. We show the difference between spending-based and tax-based consolidations and distinguish between anticipated and unanticipated consolidations (Section 5.1). We also look at how these results depend on whether agents correctly anticipate the composition of the upcoming consolidations (Section 5.2). Finally, in Section 5.3 we study uncertainty about the timing of consolidations.

We compute the impulse responses as follows. We first simulate 100 initial periods, so that the economy starts out at the high debt fixed point, consistent with the initial value of the debt threshold. We then let the government drop the debt threshold, and plot the paths of our variables towards the new high debt fixed point that corresponds to the permanently lower debt threshold.

In the high debt fixed point, both Fundamentalists and naive expectations are correct. Given the logistic distribution of the stochastic component in utility (see Equation (39)), this implies that fractions are equal (i.e. 50-50) in this fixed point. Following a consolidation, the time lag in the performance measure governing the way fractions fluctuate (see Equations (38) and (39)) implies that agents realize whether they have been correct in their expectations about macro variables one period after the consolidation is implemented. This implies that under anticipated consolidations, the fractions will only start changing endogenously one period after the consolidations have started. This is our benchmark scenario regarding the way fractions behave and is captured by the black solid lines in all the figures in this section. In order to give more insight in the role of expectations, we also display the impulse responses that arise when we exogenously impose that all agents are Naive at the

initial fixed point and the impulse responses where all agents are initially fundamentalists.¹⁵ These cases will be plotted in dashed-dotted red and dashed blue, respectively. Finally, for comparison, in the benchmark cases of Section 5.1 we also plot the responses under rational expectations in green.

5.1 No composition uncertainty

We start with the benchmark cases where consolidations are either always spending-based or always tax-based, and where there is no uncertainty about this composition.

5.1.1 Anticipated consolidations

First, consider the case where the government makes credible announcements about the current debt threshold in every period, so that fundamentalists always see consolidations coming. In particular, we calculate impulse responses for the case where the economy starts out at the high debt fixed point corresponding to a debt threshold of 80% of GDP ($\hat{DT}_t = 0.8 - 0.66 = 0.14$), and where in period 0 the government lowers the debt threshold to 70% of GDP ($\hat{DT}_t = 0.04$).¹⁶

Figure 2 presents impulse responses of correctly anticipated spending-based consolidations. That is, in this figure, the government responds to debt with government spending only, $\zeta = 1$, and when the drop in the debt threshold is announced, Fundamentalists anticipate spending-based consolidations, $\alpha^* = 1$. The reaction coefficient to debt is given by $\gamma_1 = 0.2$. In Appendix C.2, we discuss what happens when the government implements stronger consolidations, and instead sets $\gamma_1 = 0.5$.

First focusing on the benchmark behavioral model we see in the top left panel of Figure 2 that in period 1, the period that consolidation is expected by Fundamentalists but not yet implemented, an expansion in output occurs (black solid line). This is in line with Proposition 1, since we are considering $\alpha^* = 1$. As can be seen in Equation (43), the effect of the shock on output in period 1 is scaled by the fraction of Fundamentalists. When all agents are Naive in period 1, nobody expects consolidations to occur in period 2 and output stays unaffected initially (red dash-dotted line). When all agents are initially Fundamentalists (blue dashed line), they all expect consolidations, which results in a larger expansion in output. Under rational expectations (green) output jumps already in period 0, since fully rational agents better take account of the future evolution of debt

¹⁵Note that since Fundamentalists and Naive agents have the same expectations in the high debt fixed point, exogenously changing the fractions of the two types does not alter aggregate expectations. All other variables therefore remain at their high debt fixed point values when we do this.

¹⁶Note that \hat{DT}_t is measured in deviation from the steady state around which the model has been log-linearized. The assumed parametrization results in a steady state debt ratio (and thereby debt threshold) of 0.66.

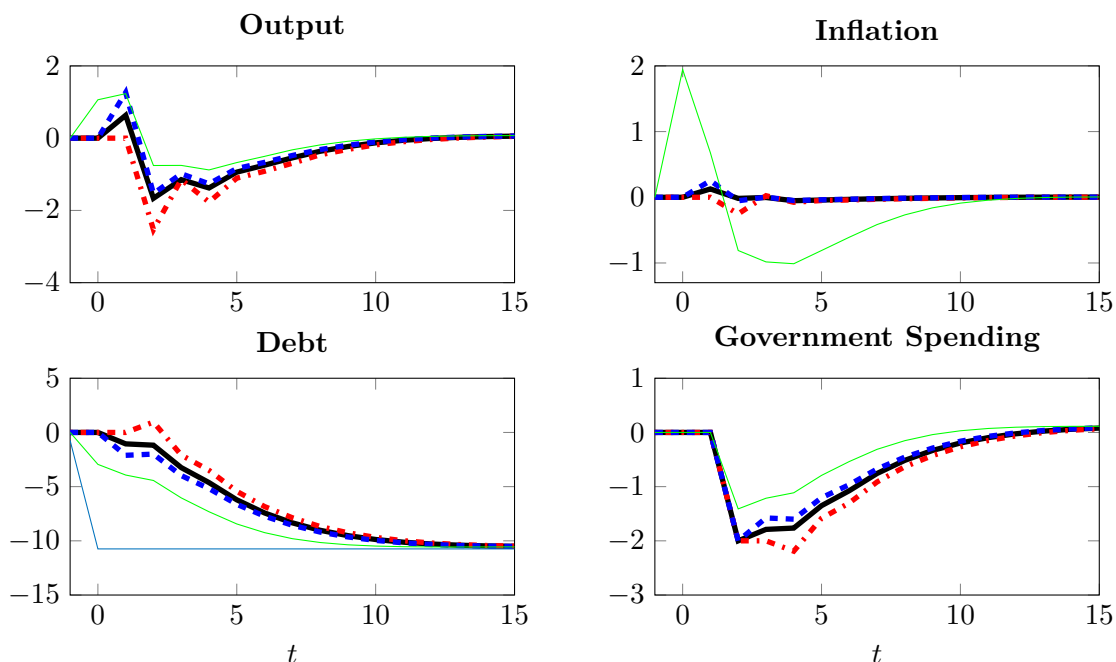


Figure 2: Impulse responses to debt threshold shock for correctly anticipated spending-based consolidations. The benchmark behavioral model is plotted in black, the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive, and the case of rational expectations is plotted in green. The debt threshold is plotted in blue in the bottom left panel.

and government spending than Fundamentalists and hence immediately adjust their expectations when the debt threshold is lowered.

Considering all 15 periods, it is clear that the initial expansion upon anticipating future consolidations plays an important role in determining how deep the recession will be when consolidations are implemented. When everybody is Naive up to period 2, and no initial expansion occurs, output falls to a considerably lower level than in the other cases. In the rational expectation case on the other hand, where output was booming for two periods, the recession is not so deep.¹⁷

The top right panel shows that the effect on inflation is qualitatively similar to that on output, which also is in line with the theoretical results of Section 4.1. However, under rational expectations, inflation is substantially more volatile than in all cases of our behavioral model. This is because both Naive agents and Fundamentalists initially expect inflation to remain on target.¹⁸ Since actual inflation largely depends on expected inflation, zero expected inflation results in a muted inflation response in our behavioral model. Under RE instead, the future debt and spending dynamics that

¹⁷We also simulated the model for the case where fully rational agents only anticipate upcoming consolidations in period 1. In that case the impulse response of output looks very similar to that of the behavioral models where initially all agents are fundamentalists (dashed blue curve). We can therefore conclude that the milder recession under RE observed in Figure 2 is largely driven by the extra period of anticipation.

¹⁸As discussed in Section 3.5, Fundamentalists expect zero inflation because they do not take account of the future evolution of fiscal variables.

agents account for, reflect on firms' inflation expectations, and thereby on firms' expected marginal costs, resulting in a more volatile response of inflation.

The anticipation-induced expansion in the period before implementation, under RE, in our benchmark case or when all agents are Fundamentalists, leads to a drop in the debt-ratio. This happens even before the government has initiated its spending cuts. In period 2 though, government spending is lowered, which leads to a sharp decline in output in all those three cases, which puts upward pressure on the debt to GDP ratio. Under RE, this pressure is offset by the reduction in debt service costs that follows from the drop in inflation and an active monetary policy. It can therefore be seen in the bottom left panel of Figure 2, that debt under the green curve keeps falling rapidly. On the other hand, when all agents are initially Naive (red), debt initially rises because of the deeper recession (caused by the lack of an initial boom in output) and because of the more moderate response of inflation. However, as spending is cut even further, the debt ratio starts to drop towards its new fixed point value, also in this case.

From Section 4.3 we know that for spending-based consolidations with moderately low values of γ_1 , the largest eigenvalue in the high debt fixed point is real and positive. In the bottom left panel of Figure 2 we indeed see that debt converges monotonically to its fixed point value in all cases, and that it does not cross the debt threshold. Therefore, even though debt is considerably reduced after 10 quarters, the government will keep responding to debt.

Next, we turn to the case of tax-based consolidations. In Figure 3 we present impulse responses for the case of $\zeta = \alpha^* = 0$. First, as formalized in Proposition 1, there is now a contraction instead of an expansion in output in period 1 (i.e. before implementation) in our benchmark scenario, in the case where initially all agents are Fundamentalists, and in the RE model. This pushes the debt ratio upward. Secondly, in Period 2, when the tax-based consolidations are implemented, the debt ratio decreases more than under spending-based consolidations, in line with Proposition 2. Again the initial impact on output, owing to anticipation effects, is stronger under RE, and inflation is more volatile in this case.

Contrary to the case of spending-based consolidations, contractions in our behavioral model are milder under tax-based consolidations compared to the RE case. This also allows the debt ratio to fall faster in the behavioral model. The abrupt increase in marginal costs - and hence in inflation - in the RE model causes a strong increase in debt service costs, which amplify contractions and delay the drop of the debt ratio. This makes higher tax hikes necessary and causes the consolidation to last longer.

In order to further explore the effects of the two types of consolidations both in short-run and

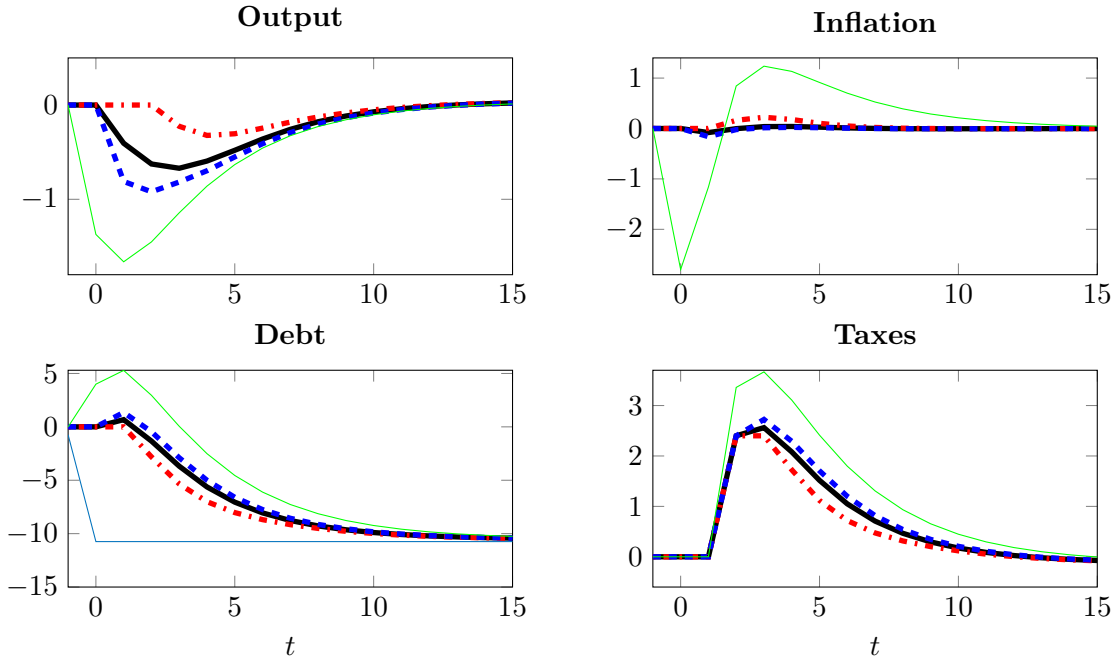


Figure 3: Impulse responses to debt threshold shock for correctly anticipated tax-based consolidations. The benchmark behavioral model is plotted in black, the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive, and the case of rational expectations is plotted in green. The debt threshold is plotted in blue in the bottom left panel.

the longer-run, we compute the impact and the present value output multipliers.¹⁹ The reported multipliers correspond to the parametrization presented in Table 1 and to our benchmark scenario regarding the behavior of fractions of agents in the periods before implementation. Looking at anticipated consolidations in panel (a) of Table 2, it is clear that spending-based consolidations cause deeper and more persistent recessions in our behavioral model. In Table 3 it can further be seen that in the long run the same holds under rational expectations, but that the impact multiplier under tax-based consolidations is more negative than the impact multiplier under spending-based consolidations in that case.

5.1.2 Unanticipated consolidations

Let us now consider the case of *unanticipated* consolidations. This will help highlight the anticipation effects of the previous subsection. We model unanticipated consolidations by a drop in the debt

¹⁹We compute the present value fiscal multipliers as in Mountford and Uhlig (2009) and Bi et al. (2013): $\Gamma_{t+k}^y = \sum_{j=0}^k (\prod_{i=0}^j r_{t+i}^{-1}) (Y_{t+j}^{shock} - Y_{t+j}^{no}) / \sum_{j=0}^k (\prod_{i=0}^j r_{t+i}^{-1}) (x_{t+j}^{shock})$, where r_t is the real interest rate, and x denotes the type of fiscal consolidation: $x_t = \tau_t \bar{H} \bar{w}$ (change in tax income due to tax rate change) for tax-based consolidations and $x_t = -G_t$ for spending-based ones. With our log-linear approximations these multipliers reduce to $\Gamma_{t+k}^y = \sum_{j=0}^k (\prod_{i=0}^j r_{t+i}^{-1}) (\hat{Y}_{t+j}^{shock}) / \sum_{j=0}^k (\prod_{i=0}^j r_{t+i}^{-1}) (\bar{w} \hat{\tau}_{t+j}^{shock})$ for tax-based- and $\Gamma_{t+k}^y = \sum_{j=0}^k (\prod_{i=0}^j r_{t+i}^{-1}) (\hat{Y}_{t+j}^{shock}) / \sum_{j=0}^k (\prod_{i=0}^j r_{t+i}^{-1}) (\hat{g}_{t+j}^{shock} + \bar{g} \hat{Y}_{t+j}^{shock})$ for spending-based consolidations.

Panel (a): no composition uncertainty					
		1qr	4qr	8qr	12qr
$\frac{\Delta Y}{\Delta G}$	Anticipated	-0.71	-0.64	-0.63	-0.63
	Unanticipated	-1.00	-0.78	-0.74	-0.73
$\frac{\Delta Y}{\Delta \tau}$	Anticipated	-0.31	-0.33	-0.36	-0.36
	Unanticipated	0	-0.16	-0.21	-0.22
Panel (b): composition change					
		1qr	4qr	8qr	12qr
$\frac{\Delta Y}{\Delta G}$	Anticipated	-1.17	-0.73	-0.68	-0.66
	Unanticipated	-1.00	-0.77	-0.71	-0.68
$\frac{\Delta Y}{\Delta \tau}$	Anticipated	0.49	0.58	0.62	0.56
	Unanticipated	0.09	-0.08	-0.12	-0.10

Table 2: Output multipliers for benchmark behavioral model

		1qr	4qr	8qr	12qr
$\frac{\Delta Y}{\Delta G}$	Anticipated	-0.49	-0.56	-0.63	-0.64
	Unanticipated	-0.41	-0.54	-0.61	-0.62
$\frac{\Delta Y}{\Delta \tau}$	Anticipated	-0.51	-0.38	-0.37	-0.38
	Unanticipated	-0.46	-0.38	-0.37	-0.38

Table 3: Output multipliers for rational expectations model with no composition uncertainty

threshold that is not only unanticipated, but also unannounced. More specifically, we let our model again start in the high debt fixed point and let the government lower its debt threshold from 80% of GDP to 70% of GDP in period 0. However, the lowering of the debt threshold is not announced, so that fundamentalists only become aware of the lower debt threshold after consolidations are implemented in period 2.

In Figures 4 and 5 we plot impulse responses of unanticipated spending-based and tax-based consolidations, respectively. It can be seen here, that since consolidations are unanticipated, the anticipation affects described in Proposition 1, are absent. Instead, the model remains at the high debt fixed point corresponding to the old debt threshold in period 1. In period 2, consolidations are implemented, but still not expected, so that all variables initially follow the paths of the red dashed lines in Figures 2 and 3 that correspond to all naive initial expectations.

In the next periods, both Fundamentalists and Naive agents start adjusting their expectations. The impulse responses then depend on the fraction of Naive agents in the economy as can be seen by comparing the red, black, and blue curves of the behavioral model. Note that since under unanticipated consolidations the economy is shocked in period 2, rather than period 0, we correspondingly adjust the periods for which we exogenously fix the fractions at all Naive or all Fundamentalist to obtain the red and blue curves.

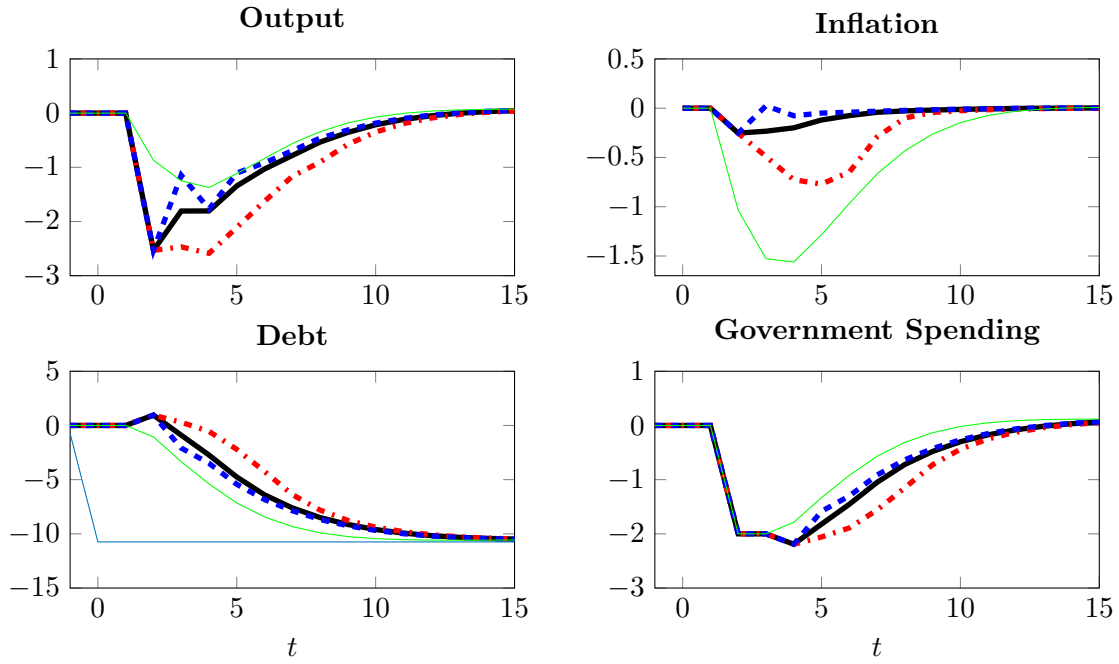


Figure 4: Impulse responses to debt threshold shock for unanticipated spending-based consolidations. The benchmark behavioral model is plotted in black, the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive, and the case of rational expectations is plotted in green. The debt threshold is plotted in blue in the bottom left panel.

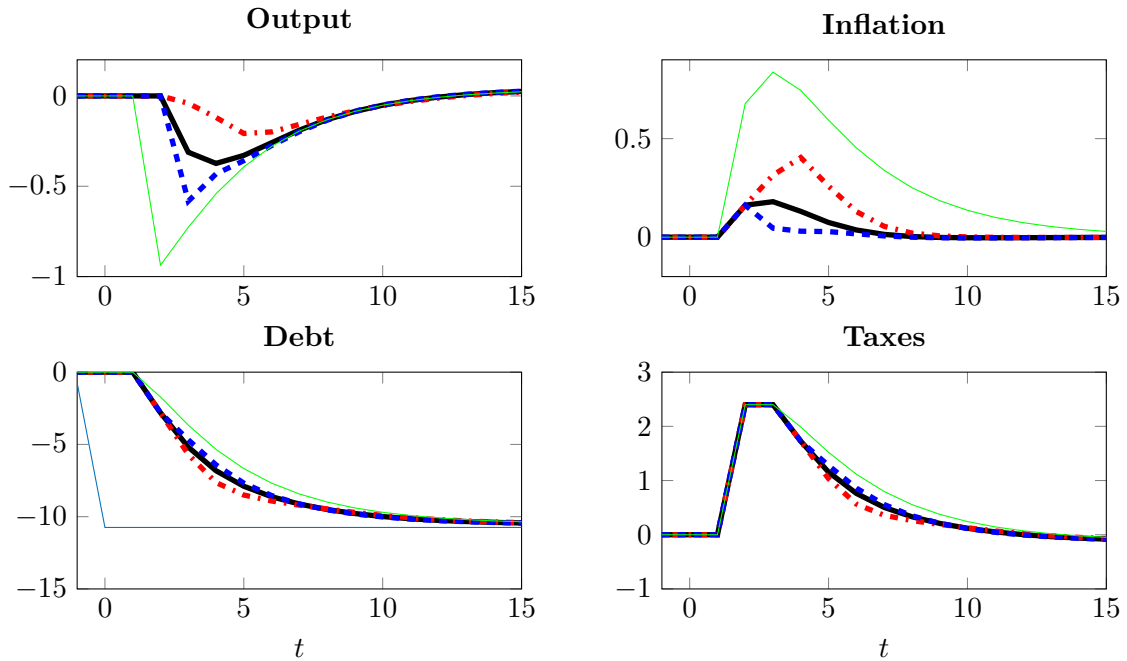


Figure 5: Impulse responses to debt threshold shock for unanticipated tax-based consolidations. The benchmark behavioral model is plotted in black, the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive, and the case of rational expectations is plotted in green. The debt threshold is plotted in blue in the bottom left panel.

First, consider the case of spending-based consolidations (Figure 4). Here, our Benchmark case (black), and the case where initially all agents are Fundamentalists (blue) closely follow the case where fundamentalists would have anticipated consolidations, but where all agents were naive in the two periods following the announcement (red curves in Figure 2). However, when all agents are Naive during the initial periods of consolidations (red curves), an even larger wave of pessimism in output arises, that causes slower debt reduction. Finally, considering the green curves of rational expectations, it can be seen that output falls much less in the initial period of consolidation. This is because rational agents realize already in this period that the debt threshold must have dropped, and adjust their expectations and consumption accordingly. However, in the next period their consumption is very close to that of fundamentalists (blue) who then also anticipate consolidations to continue. The more moderate initial recession under rational expectations has however led to a reduction rather than an increase in debt in period 2, so that in later periods smaller spending cuts are required.

Comparing the multipliers with the case of anticipated spending-based consolidation in panel (a) in Table 2, it is clear that when spending cuts are not anticipated the contraction in output is deeper. This delays the drop in the debt ratio which makes further spending cuts necessary and increases pessimism in the economy.

Next we turn to tax-based consolidations (Figure 5). In the first period of consolidations (period 2), again only agents with rational expectations (green) change their expectations and consumption, while output remains at its fixed point level for one more period in our boundedly rational model, where agents do not realize the debt threshold has dropped yet.²⁰ In later periods, the severity of the recession and the rise in inflation again depends on the initial fractions of Naive agents and Fundamentalists. In general however, unanticipated tax-based consolidations imply a less severe recession and faster debt reduction than the anticipated ones in Figure 3.

Contrary to the case of spending-based consolidations, our results therefore show that unanticipated tax-based consolidations are preferable to anticipated ones. This is also reflected in the multipliers in panel (a) in Table 2. Here it can be seen the induced contraction in output after unexpected tax hikes is smaller than the contraction under anticipated tax hikes. The intuition is

²⁰Note that the result that output does not change as unexpected tax hikes are implemented for the first time depends on the specification of the interest rate rule. As a robustness check, we have also simulated our model with a contemporaneous Taylor rule, where the nominal interest rate responds to contemporaneous inflation. In that case the increase in inflation caused by the tax increase results in an increase in the nominal interest rate and hence in an immediate drop in output. Because of the moderate response of inflation in our behavioral model, this effect is however not very large. Furthermore, as in later periods inflation expectations become aligned with actual inflation because of the presence of Naive agents, the differences between the forward-looking and contemporaneous Taylor rule start to disappear.

that when tax hikes are not expected, agents do not decrease their labor supply neither before, nor upon implementation. The same holds for their consumption. In the following periods the existence of Naive agents leads to a muted decrease in labor supply and in consumption. Consequently, the induced contraction is milder than under anticipated tax hikes which allows for a faster drop in the debt ratio and, ultimately, for shorter consolidations.

The above is in line with the result of Proposition 1 that anticipated spending-based consolidations positively affect output and help to reduce debt, while anticipated tax-based consolidations do the opposite. Looking at anticipated and unanticipated consolidations under rational expectations, in Table 3, it can be seen that for tax-based consolidations, the anticipation effect only matters for the impact multiplier, and that for spending-based consolidations anticipation effects actually imply slightly more negative multipliers. The more moderate recession under rational expectations observed in Figure 3 is therefore due to the fact that the reduction in debt during the anticipation periods implies lower future spending cuts, and not because the multipliers were positively affected by the anticipation of consolidations.

5.2 Composition surprise

In this subsection we investigate the effect of uncertainty about the composition of consolidations. We do this by calculating impulse responses for the case where, as in Section 5.1, the debt threshold is dropped 2 periods before the consolidation, but where the composition of the consolidation (ζ) is changed in the period where the consolidation first starts. As described in Section 3.3, the change in the composition is not announced and comes as a surprise to all agents in the economy.

5.2.1 Anticipated consolidations

We first study surprise changes in the composition of consolidations in the case of anticipated consolidations. That is, Fundamentalists know that the debt threshold has dropped, and that consolidations will be implemented, but they turn out to be wrong about the composition they expect the consolidation to have. In particular, we first let the economy start out in the high debt fixed point where taxes are the main instrument of the government ($\zeta = 0$). In period 0 it announces that it will drop the debt threshold from 80% to 70% of GDP, and that in two periods from now the consolidation will be tax-based. However, in period 2, where consolidations are implemented for the first time, the government suddenly changes the composition to $\zeta = 1$, and actually implements spending-based consolidations. The impulse responses are displayed in Figure 6. Second, we perform the same exercise but now assuming that spending was initially the main instrument. In this case,

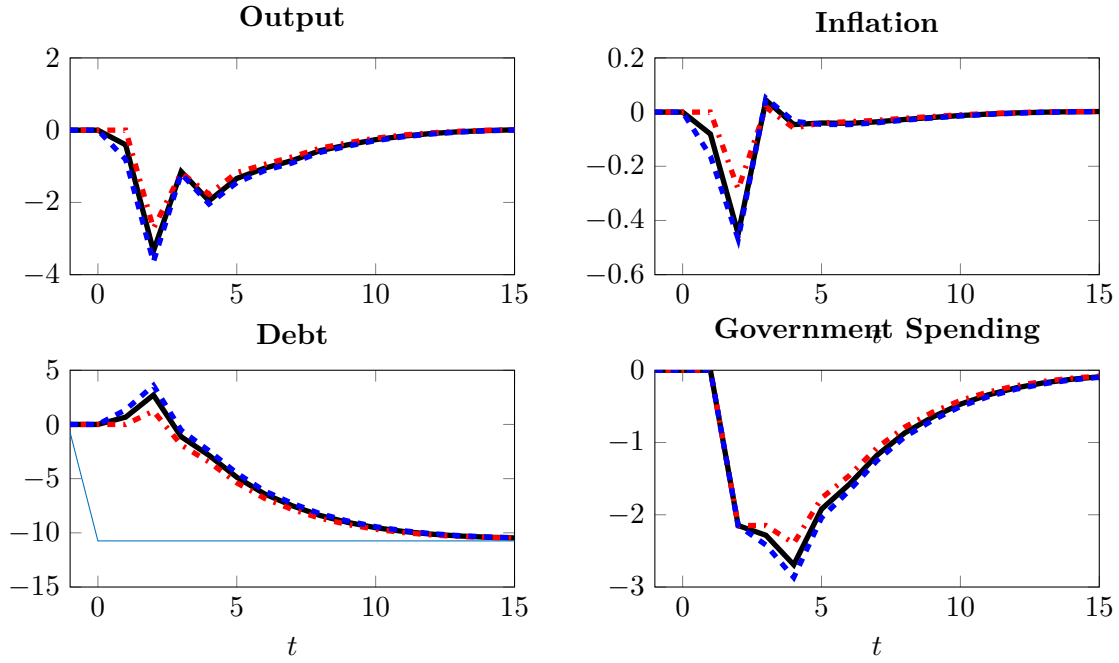


Figure 6: Impulse responses to debt threshold shock for spending-based consolidations that were anticipated to be tax-based ($\alpha^* = 0$). The benchmark behavioral model is plotted in black, and the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive. The debt threshold is plotted in blue in the bottom left panel.

Fundamentalists anticipated consolidations to be spending-based, but when the implementation day arrives, the government surprises agents in the economy by increasing taxes instead. The impulse responses are plotted in Figure 7.

In period 1, no consolidation are implemented yet, but Fundamentalists expect tax-based consolidation in Figure 6 and spending-based consolidations in Figure 7. During the anticipation period (i.e. period 1) the dynamics are thus the same as in Figures 3 and 2, respectively. Comparing the dynamics in period 2 in Figure 7 with those in Figure 2, we see that when the consolidation is implemented, debt is reduced by more in Figure 7. This is in line with Proposition 2, which says that for a given α^* , *initially*, tax-based consolidations always lead to lower debt than spending-based consolidations. This is also reflected in Figure 6 where debt in period 2 is higher than in Figure 3.

We further observe that when the government implements spending-based consolidations while agents were expecting tax-based consolidations (Figure 6) a severe recession arises (that is deeper than when agents would have expected spending-based consolidations). This is so because when Fundamentalists turn out to be wrong about the consolidations that they were expecting, more agents switch to the naive rule, coordinating on a wave of pessimism. On the other hand, when the government implements tax-based consolidations while agents were expecting spending-based

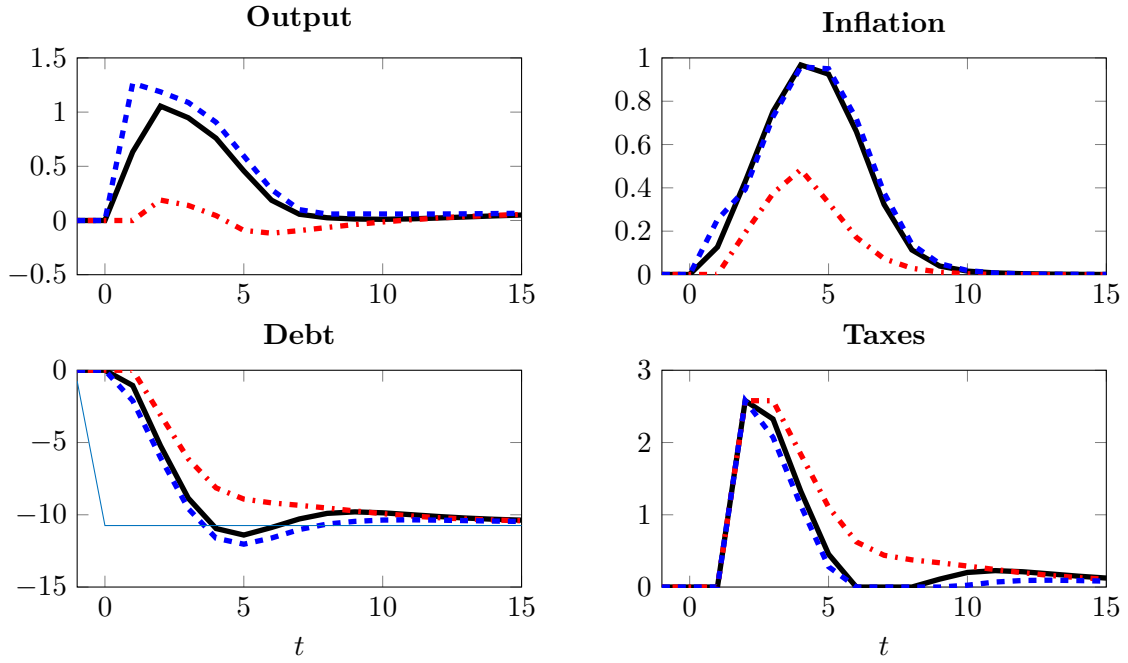


Figure 7: Impulse responses to debt threshold shock for tax-based consolidations that were anticipated to be spending-based ($\alpha^* = 1$). The benchmark behavioral model is plotted in black, and the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive. The debt threshold is plotted in blue in the bottom left panel.

consolidations (Figure 7), a boom in output arises that causes fast debt reduction. Wrong beliefs in this case create optimism in the economy after implementation and lead to an increase in the tax base. As a result debt drops faster and consolidations last for less periods. Therefore, it is beneficial for the economy when the government reneges on its commitment to cut spending and implements tax hikes instead.

Looking at the multipliers of anticipated consolidations with composition change in panel (b) of Table 2, we see that spending-based consolidations, when Fundamentalists anticipate tax hikes instead, are more contractionary than in case where they correctly anticipate spending cuts (panel (a)). Looking at tax-based consolidations when Fundamentalists anticipate spending cuts, the multipliers indicate that in this case consolidations are in fact expansionary, as also observed in Figure 7.

5.2.2 Unanticipated consolidations

Just as in the case of no composition uncertainty, graphs of unanticipated consolidations look similar to those of anticipated consolidations where initially all agents were naive (dashed-dotted red curves in Figures 6 and 7). For the sake of brevity we therefore do not plot these graphs, but

instead comment on the multipliers of unanticipated consolidations in case of a composition surprise, presented in panel (b) of Table 2. Comparing these multipliers with the multipliers obtained with no composition change, in panel (a), we see that multipliers are much less affected by the composition change than in case of anticipated consolidators. This confirms the discussion above, that the changes in multipliers under anticipated consolidations with composition surprises mainly come from anticipation effects and subsequent waves of optimism and pessimism, and not so much from the composition change itself.

5.3 Uncertainty about timing of consolidation

In the previous sections, we assumed that consolidations were either anticipated by fundamentalists or unanticipated. In this section, we study the in between case, where the government is not perfectly transparent about its current debt threshold, but where Fundamentalists are aware that the government is considering to drop the debt threshold either in the current period or in the near future. This can be thought of as speculation in the media that the debt ratio is too high and consolidations are necessary, but where it is not clear exactly when the government will start these consolidations.

In particular, we model the case where Fundamentalists believe from period 1 onward that the debt threshold might have dropped in the previous period with a 50% probability. That is, they put 50% weight on the possibility that everything remains as it was before, and 50% weight on the possibility that consolidations will start tomorrow. However, consolidations only actually start in period 5 (i.e. the debt limit dropped in period 3).

	1qr	4qr	8qr	12qr
$\frac{\Delta Y}{\Delta G}$	-0.83	-0.67	-0.65	-0.65
$\frac{\Delta Y}{\Delta \tau}$	-0.35	-0.35	-0.37	-0.37

Table 4: Output multipliers in case of uncertainty about the time of implementation of consolidations. From period 1 onwards fundamentalists expect that the debt threshold might have been dropped in the previous period with a 50% probability, while the actual drop only takes place in period 3.

In Figure 8 we plot the case of spending-based consolidations. Comparing this figure with Figure 2 we see that the initial anticipation effects in period 1 are milder. This is because fundamentalists now expect consolidations only with a 50% probability rather than with certainty. However, the initial boom in output slowly grows larger as Fundamentalists keep expecting consolidations that are still not implemented. Additionally, so long as consolidations are postponed further, fundamentalists are wrong in their expectations. Hence, more and more agents become Naive and thus optimistic

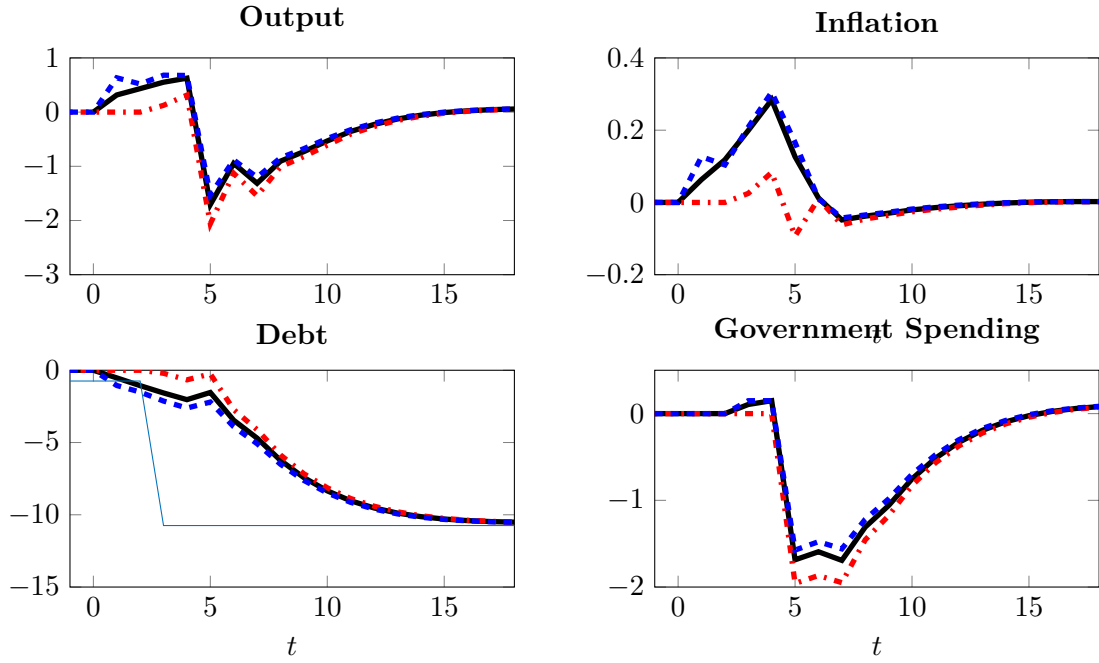


Figure 8: Impulse responses to debt threshold shock for correctly anticipated spending-based consolidations. In the Figure $\gamma_1 = 0.5$ instead of 0.2. The benchmark behavioral model is plotted in black, and the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive. The debt threshold is plotted in blue in the bottom left panel.

about output. This rise in output leads the debt to GDP ratio to keep going down, and even fall below the debt threshold. For this reason, government spending is increased rather than decreased in period 3 and 4, amplifying the rise in output.

Looking at tax-based consolidations in Figure 9, it can be seen that timing uncertainty regarding their implementation causes a persistent contraction in output periods before they are in fact implemented. This is for reasons mentioned in the sections above and which relate to a decrease in the consumption of Fundamentalists. As Fundamentalists continue to be wrong about the implementation of consolidations, the fraction of Naive agents increases and thereby pessimism in the economy. As a consequence, the debt to GDP ratio rises during the periods of anticipation.

In Table 4 we present the present value multipliers corresponding to Figures 8 and 9. Comparing these with the multiplier of correctly anticipated consolidations in panel (a) of Table 2, we see that multipliers in case of spending-based consolidations become more negative under timing uncertainty. However, as mentioned above, smaller spending cuts are needed because of the initial fall in debt, making the recession in output milder than in Figure 2. In case of tax-based consolidations, it can be seen that multipliers become more negative as well under timing-uncertainty. This is because of the adverse effects that the longer lasting anticipation has on confidence in the economy.

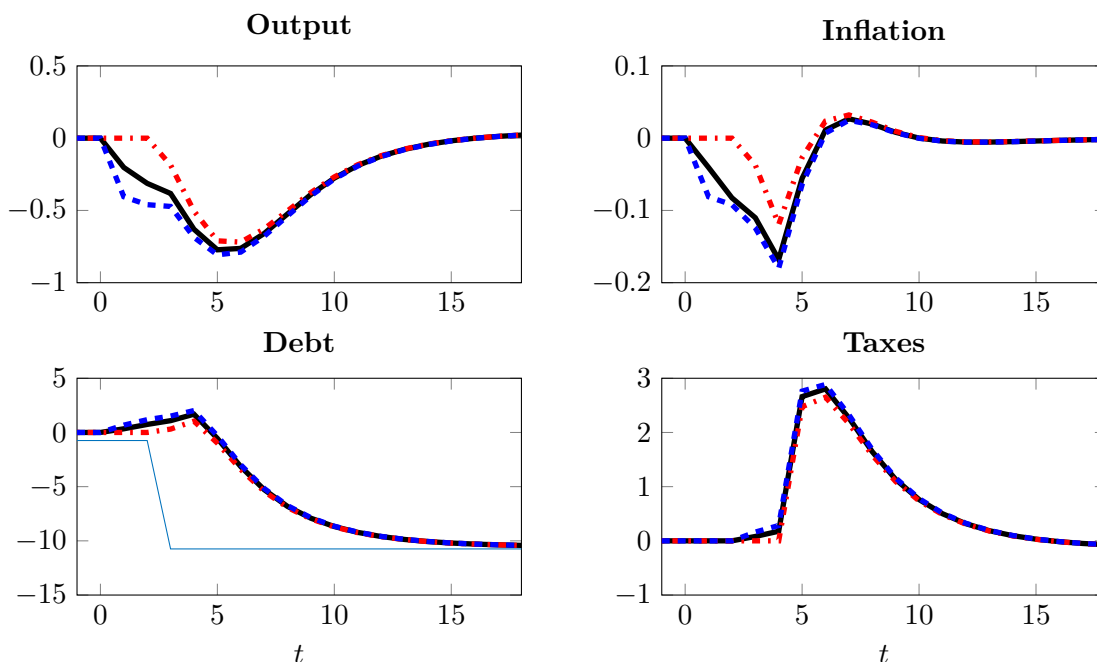


Figure 9: Impulse responses to debt threshold shock for correctly anticipated strong tax-based consolidations. In the Figure $\gamma_1 = 0.5$ instead of 0.2. The benchmark behavioral model is plotted in black, and the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive. The debt threshold is plotted in blue in the bottom left panel.

6 Spending-based vs Tax-based Consolidations: discussion

The impulse response analysis discussed in the sections above shows that, in our behavioral model, tax-based consolidations lead to milder contractions than spending-based consolidations. This is a robust result holding regardless whether consolidations are anticipated or not, or whether agents are certain about the timing and composition of an imminent consolidation or not. As argued above, spending-based consolidations lead to deeper and more persistent recessions and as such they tend to last longer. Under rational expectations though, tax-based consolidations cause deeper recessions on impact than spending-based ones.

In our behavioral model, the milder contractions under tax-based consolidations are mainly due to the bounded rationality of and heterogeneity in expectations, and their implications for each type's consumption and labor supply decisions (due to distortionary taxes). When the government increases taxes, Naive agents do not necessarily decrease their consumption as Fundamentalists do, nor do they decrease their labor supply. They will only do so to the extent that they are already observing a drop in output. Hence naive agents will not initiate the recession. When all agents are Fundamentalists when consolidations are implemented, a cut in consumption and labor does occur. However, since Fundamentalists are also boundedly rational and do not fully account for

the future paths of debt and taxes and corresponding wealth effects, they also do not decrease their consumption by as much as fully rational agents would. Given that in our behavioral model the initial contraction in output is milder, the tax base is not decreased substantially. This implies faster debt reduction and a quicker reversal (drop) in taxes. This allows for an increase in consumption and a faster recovery.

Under anticipated spending-based consolidations instead, the spending cuts lead to an immediate drop in output upon implementation that is only to a small extent offset by an increase in consumption. This is again first of all because naive agents do not respond at all initially, and secondly, because Fundamentalists do not fully take account of the future paths of fiscal variables either. The existence of Naive agents, who expect output to stay low, furthermore increases pessimism in the economy slowing down the recovery and forcing consolidations to last longer. Moreover, inflation and expected inflation remain relatively close to zero given that both types have initially been expecting zero inflation. This means that the real interest rate does not fall as much in response to the spending cuts as it would have with fully rational agents. Consequently, this channel does not significantly induce agents to increase their consumption, and pessimism in output remains. This causes the debt ratio to fall at a slower pace than under tax-based consolidations.

7 Conclusions

In this paper we have explored the effects of fiscal consolidations when agents are boundedly rational and have heterogeneous expectations in the spirit of Brock and Hommes (1997). Agents can switch between two types, namely, the Fundamentalist and the Naive. The former type consisted of forward looking agents that trust the commitments of the government, whereas the latter consisted of backward looking agents.

The fiscal authority was assumed to engineer a consolidation once the debt ratio exceeds an announced debt threshold, with a lag. Consolidations were implemented either through spending cuts or tax increases. We have explored what happens when prior to the consolidation, agents were uncertain or wrong about the timing and composition of the consolidations.

Our first finding was that in our behavioral model tax-based consolidations generally outperform spending-based ones. We showed that the type of consolidation that was anticipated was crucial in determining whether the consolidation would trigger expansions or abrupt contractions in output so long as it lasts. Moreover, whether the type of consolidation anticipated was correct or not, determined its duration. Consolidations last longer when agents wrongly anticipate them to be

tax-based, but they turn out to be spending-based. This is due to the persistent contraction in output triggered by the implemented spending cuts and expected tax hikes and a subsequent wave of pessimism. On the contrary, when agents expect spending cuts but the government implements tax increases, a wave of optimism can arise that results in a boom in output that persists even during the periods of higher taxes.

The model was complex in its dynamics and we kept the analysis as simple as possible. Cases like the effect of the zero lower bound on the potential of a consolidation to be expansionary and/or successful in stabilizing debt, in a heterogeneous agents model, deserve further research.

A Model

A.1 Zero inflation steady state

In this section, we derive the steady state of the non-linear model, where gross inflation equals 1, and where we normalize technology to $A = 1$.

Evaluating (14) at the zero inflation steady state gives

$$\bar{m}c = \frac{\theta - 1}{\theta}. \quad (\text{A.1})$$

From (7) it follows that in this steady state we must have

$$1 + \bar{i} = \frac{1}{\beta}. \quad (\text{A.2})$$

Furthermore, from (10) it follows that

$$\bar{H} = \bar{Y}. \quad (\text{A.3})$$

Next, we solve the steady state aggregate resource constraint, (19), for consumption, and write

$$\bar{C} = \bar{Y}(1 - \bar{g}). \quad (\text{A.4})$$

Plugging in these steady state labor and consumption levels in the steady state version of (8) gives

$$\bar{w} = \frac{\bar{Y}^\eta (\bar{Y}(1 - \bar{g}))^\sigma}{1 - \bar{\tau}} = \frac{\bar{Y}^{\eta + \sigma} (1 - \bar{g})^\sigma}{1 - \bar{\tau}} = \frac{\theta - 1}{\theta}, \quad (\text{A.5})$$

where the last equality follows from the fact that $\bar{w} = \bar{m}c$ and from (A.1). We can thus write

$$\bar{Y} = \left(\frac{\theta - 1}{\theta} \frac{1 - \bar{\tau}}{(1 - \bar{g})^\sigma} \right)^{\frac{1}{\eta + \sigma}}. \quad (\text{A.6})$$

Then we turn to the government budget constraint. In steady state (16) reduces to

$$\bar{b} = \bar{g} - \bar{\tau} \frac{\theta - 1}{\theta} + (1 + \bar{i})\bar{b}, \quad (\text{A.7})$$

which gives

$$\bar{b} = \beta \frac{(\bar{\tau} \frac{\theta - 1}{\theta} - \bar{g})}{1 - \beta}, \quad (\text{A.8})$$

where we used (A.2) to substitute for the interest rate.

Steady state government spending and taxes are given by

$$\bar{g} = g_1 - \zeta\gamma_1 \max(0, \bar{b} - \bar{DT}), \quad (\text{A.9})$$

and

$$\bar{\tau} = \tau_1 + (1 - \zeta)\gamma_2 \max(0, \bar{b} - \bar{DT}). \quad (\text{A.10})$$

Assuming that the steady state debt threshold equals steady state debt, this reduces to

$$\bar{g} = g_1, \quad (\text{A.11})$$

and

$$\bar{\tau} = \tau_1. \quad (\text{A.12})$$

A.2 Fundamentalists' expectations about output and inflation

From (31) it follows that in a state of the economy where all variables are constant over time, we must have

$$i = \phi_\pi \pi. \quad (\text{A.13})$$

Furthermore, (29) reduces in such a fixed point state to

$$Y = Y - \frac{1}{\sigma}(i - \pi) - \frac{1}{1 - \bar{g}}(g - g), \quad (\text{A.14})$$

from which it follows that

$$\pi = i. \quad (\text{A.15})$$

(A.13) and (A.15) can only both hold (assuming $\phi_\pi \neq 1$) if

$$\pi = i = 0. \quad (\text{A.16})$$

Therefore, Fundamentalists inflation expectations satisfy $E_t^f \pi_{t+1} = 0$. Using this in (30), it follows that

$$0 = \kappa(\sigma + \eta)Y - \sigma\kappa \frac{g}{1 - \bar{g}} + \kappa \frac{\tau}{1 - \bar{\tau}}. \quad (\text{A.17})$$

Output expectations of Fundamentalists therefore satisfy

$$E_t^F \hat{Y}_{t+1} = \frac{\sigma}{\sigma + \eta} \frac{E_t^F \tilde{g}_{t+1}}{1 - \bar{g}} - \frac{1}{\sigma + \eta} \frac{E_t^F \tilde{\tau}_{t+1}}{1 - \bar{\tau}}. \quad (\text{A.18})$$

Plugging in (34) and (35) gives

$$E_t^F \hat{Y}_{t+1} = - \left(\frac{\sigma}{\eta + \sigma} \frac{1}{1 - \bar{g}} \alpha_t \gamma_1 + \frac{1}{\eta + \sigma} \frac{1}{1 - \bar{\tau}} (1 - \alpha_t) \gamma_2 \right) \max(0, \tilde{b}_{t-1} - \tilde{D}T_{t-1}). \quad (\text{A.19})$$

A.3 Model summary

Our system is piecewise linear. The equation for inflation and output depend on the level of the debt to GDP ratio in the last two periods, even though the debt ratio does not show up in the equations explicitly. Below we give a summary of the equations governing inflation and output in the four regions of our model.

1. When debt is low ($\tilde{b}_{t-2} < \tilde{D}T_{t-2}$ and $\tilde{b}_{t-1} < \tilde{D}T_{t-1}$) we obtain, by plugging in monetary and fiscal policy in (29) and (30), the following system for inflation and output

$$\hat{Y}_t = \bar{E}_t[\hat{Y}_{t+1}] - \frac{\phi_\pi - 1}{\sigma} \bar{E}_t[\pi_{t+1}] - \frac{1}{1 - \bar{g}} \bar{E}_t[\tilde{g}_{t+1}], \quad (\text{A.20})$$

$$\pi_t = \beta \bar{E}_t[\pi_{t+1}] + \kappa(\sigma + \eta) \hat{Y}_t. \quad (\text{A.21})$$

In this region of low debt, Fundamentalists expect all variables to be at their steady state value of 0, so that aggregate expectations are given by

$$\bar{E}_t \tilde{g}_{t+1} = n_t^N \tilde{g}_{t-1}, \quad (\text{A.22})$$

$$\bar{E}_t \pi_{t+1} = n_t^N \pi_{t-1}, \quad (\text{A.23})$$

$$\bar{E}_t \hat{Y}_{t+1} = n_t^N \hat{Y}_{t-1}. \quad (\text{A.24})$$

2. When debt has just crossed the critical boundary, but consolidation is not yet implemented ($\tilde{b}_{t-2} < \tilde{D}T_{t-2}$, but $\tilde{b}_{t-1} > \tilde{D}T_{t-1}$), then (A.20), (A.21) and (A.23) still hold, while for aggregate government spending expectations we then have

$$\bar{E}_t \tilde{g}_{t+1} = n_t^N \tilde{g}_{t-1} - (1 - n_t^N) \alpha_t \gamma_1 (\tilde{b}_{t-1} - \tilde{D}T_{t-1}). \quad (\text{A.25})$$

This is because Fundamentalists expect a consolidation to start in the next period. As regards

aggregate expectations about output, they are formed as follows

$$\bar{E}_t Y_{t+1} = n_t^N Y_{t-1} - (1 - n_t^N) \frac{1}{\sigma + \eta} \left(\frac{\sigma}{1 - \bar{g}} \alpha_t \gamma_1 + \frac{1}{1 - \bar{\tau}} (1 - \alpha_t) \gamma_2 \right) (\tilde{b}_{t-1} - \tilde{D}T_{t-1}). \quad (\text{A.26})$$

3. When both $\tilde{b}_{t-2} > \tilde{D}T_{t-2}$ and $\tilde{b}_{t-1} > \hat{D}L_{t-1}$ expectations are again given by (A.23), (A.25) and (A.26), respectively. However, current output and inflation are now equal to

$$\hat{Y}_t = \bar{E}_t[\hat{Y}_{t+1}] - \frac{\phi_\pi - 1}{\sigma} \bar{E}_t[\pi_{t+1}] - \frac{1}{1 - \bar{g}} \left(\bar{E}_t[\tilde{g}_{t+1}] + \zeta \gamma_1 (\tilde{b}_{t-2} - \tilde{D}T_{t-2}) \right), \quad (\text{A.27})$$

$$\pi_t = \beta \bar{E}_t[\pi_{t+1}] + \kappa(\sigma + \eta) \hat{Y}_t + \kappa \left(\zeta \frac{\sigma \gamma_1}{1 - \bar{g}} + (1 - \zeta) \frac{\gamma_2}{1 - \bar{\tau}} \right) (\tilde{b}_{t-2} - \tilde{D}T_{t-2}). \quad (\text{A.28})$$

4. At some point, the consolidation has worked through, and the debt to GDP ratio falls again below the critical threshold. One period later, a consolidation is no longer expected for the future, but still implemented in the current period (since $\tilde{b}_{t-2} > \tilde{D}T_{t-2}$ but $\tilde{b}_{t-1} < \tilde{D}T_{t-1}$). In that case, expectations are given by (A.22), (A.23) and (A.24), while current output and inflation are given by (A.27) and (A.28).

B Proofs of propositions

B.1 Proof Proposition 1

Leading (A.25) one period, it follows that

$$\frac{\partial \bar{E}_{t+1} \tilde{g}_{t+2}}{\partial (\tilde{b}_t - \tilde{D}T_t)} = -(1 - n_{t+1}^N) \alpha^* \gamma_1. \quad (\text{B.1})$$

Similarly it follows from (A.26) that

$$\frac{\partial \bar{E}_{t+1} \hat{Y}_{t+2}}{\partial (\tilde{b}_t - \tilde{D}T_t)} = -(1 - n_{t+1}^N) \frac{1}{\sigma + \eta} \left(\frac{\sigma}{1 - \bar{g}} \alpha^* \gamma_1 + \frac{1}{1 - \bar{\tau}} (1 - \alpha^*) \gamma_2 \right) < 0. \quad (\text{B.2})$$

Meanwhile, leading (A.20) one period, we obtain

$$\begin{aligned} \frac{\partial \hat{Y}_{t+1}}{\partial (\tilde{b}_t - \tilde{D}T_t)} &= \left(\frac{\partial \bar{E}_{t+1} \hat{Y}_{t+2}}{\partial (\tilde{b}_t - \tilde{D}T_t)} - \frac{1}{1 - \bar{g}} \frac{\partial \bar{E}_{t+1} \tilde{g}_{t+2}}{\partial (\tilde{b}_t - \tilde{D}T_t)} \right) \\ &= (1 - n_{t+1}^N) \left(\frac{\eta}{\sigma + \eta} \alpha^* \frac{\gamma_1}{1 - \bar{g}} - \frac{1}{\sigma + \eta} \frac{1}{1 - \bar{\tau}} (1 - \alpha^*) \gamma_2 \right). \end{aligned} \quad (\text{B.3})$$

It follows that the effect of a debt (or debt threshold) shock on next periods output is positive,

if and only if

$$\eta\alpha^*\gamma_1\frac{1}{1-\bar{g}} > \frac{1}{1-\bar{\tau}}(1-\alpha^*)\gamma_2.$$

When $\alpha^* = 1$ this will always hold and when $\alpha^* = 0$ it will never hold. Solving for α^* gives

$$\alpha^* > \frac{\gamma_2(1-\bar{g})}{\gamma_1(1-\bar{\tau})\eta + \gamma_2(1-\bar{g})}.$$

Next we turn the effect of a debt (threshold) shock on debt on the other variables of the model.

Using (A.21), we have

$$\frac{\partial\pi_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} = \kappa(\sigma + \eta)\frac{\partial\hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)}. \quad (\text{B.4})$$

Therefore, the effect on inflation is positive, if and only the effect of the shock on output is positive.

For debt we have, using (24),

$$\begin{aligned} \frac{\partial\tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} &= \frac{1}{\beta} - \bar{\tau}\frac{\theta-1}{\theta}(\sigma + \eta)\frac{\partial\hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} - \frac{\bar{b}}{\beta}\frac{\partial\hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} - \frac{\bar{b}}{\beta}\frac{\partial\pi_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} \\ &= \frac{1}{\beta} - \left((\bar{\tau}(\sigma + \eta))\frac{\theta-1}{\theta} + \frac{\bar{b}}{\beta}(1 + \kappa(\sigma + \eta)) \right) \frac{\partial\hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)}. \end{aligned} \quad (\text{B.5})$$

We can conclude that if (B.4) is not satisfied (and the debt (threshold) shock leads to a lower output level), then an increase in \tilde{b}_{t-1} implies a more than one for one increase in \tilde{b}_t , so that $\tilde{b}_t > \tilde{b}_{t-1}$ and consolidation expectations lead to an increase in debt. If, on the other hand, (B.4) is satisfied, then the expectations of consolidations may reduce period $t + 1$ debt compared to period t debt. This happens if and only if

$$\frac{\partial\tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} = \frac{1}{\beta} - \left((\bar{\tau}(\sigma + \eta))\frac{\theta-1}{\theta} + \frac{\bar{b}}{\beta}(1 + \kappa(\sigma + \eta)) \right) \frac{\partial\hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} < 1, \quad (\text{B.6})$$

or

$$\frac{\partial\hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} > \frac{1-\beta}{\beta \left((\bar{\tau}(\sigma + \eta))\frac{\theta-1}{\theta} + \frac{\bar{b}}{\beta}(1 + \kappa(\sigma + \eta)) \right)}. \quad (\text{B.7})$$

B.2 Proof Proposition 2

We first assume spending-based consolidation. Leading (A.20) and taking the derivative, we can write

$$\begin{aligned} & \frac{\partial \hat{Y}_{t+2}}{\partial(\tilde{b}_t - \tilde{D}T_t)} \\ &= \frac{\partial \hat{Y}_{t+2}}{\partial \tilde{b}_{t+1}} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{D}T_t)} - \frac{1}{1 - \bar{g}} \gamma_1 + n_{t+2}^N \frac{\partial \hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{D}T_t)} - \frac{\phi_\pi - 1}{\sigma} n_{t+2}^N \frac{\partial \pi_{t+1}}{\partial(\tilde{b}_t - \tilde{D}T_t)}. \end{aligned} \quad (\text{B.8})$$

Here, the first term represents the effect of the expectation of fundamentalists, taking account of the fact that these are only effected by the most recent value of the debt ratio. The second term embodies the direct effect of implemented consolidations. The third and fourth term contain the effect that the changes in output and inflation in the anticipation period have on Naive expectations one period later.

Similarly, we obtain for inflation

$$\frac{\partial \pi_{t+2}}{\partial(\tilde{b}_t - \tilde{D}T_t)} = \frac{\partial \pi_{t+2}}{\partial \tilde{b}_{t+1}} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{D}T_t)} + \frac{\sigma \kappa \gamma_1}{1 - \bar{g}} + \beta n_{t+2}^N \frac{\partial \pi_{t+1}}{\partial(\tilde{b}_t - \tilde{D}T_t)} + \kappa(\sigma + \eta) \frac{\partial \hat{Y}_{t+2}}{\partial(\tilde{b}_t - \tilde{D}T_t)}. \quad (\text{B.9})$$

$\frac{\partial \hat{Y}_{t+2}}{\partial \tilde{b}_{t+1}}$ can be obtained by replacing n_{t+1}^N by n_{t+2}^N in (B.3). Updating (B.4) analogously gives $\frac{\partial \hat{\pi}_{t+2}}{\partial \tilde{b}_{t+1}}$.

Finally, we have

$$\begin{aligned} \frac{\partial \tilde{b}_{t+2}}{\partial(\tilde{b}_t - \tilde{D}T_t)} &= -\gamma_1 + \frac{1}{\beta} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{D}T_t)} - \bar{\tau} \frac{\theta - 1}{\theta} \frac{\partial \hat{m}c_{t+2}}{\partial(\tilde{b}_t - \tilde{D}T_t)} \\ &+ \frac{\bar{b}}{\beta} \left(\frac{\partial \hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{D}T_t)} - \frac{\partial \hat{Y}_{t+2}}{\partial(\tilde{b}_t - \tilde{D}T_t)} - \frac{\partial \pi_{t+2}}{\partial(\tilde{b}_t - \tilde{D}T_t)} \right), \end{aligned} \quad (\text{B.10})$$

with

$$\frac{\partial \hat{m}c_{t+2}}{\partial(\tilde{b}_t - \tilde{D}T_t)} = (\sigma + \eta) \frac{\partial \hat{Y}_{t+2}}{\partial \tilde{b}_{t+1}} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{D}T_t)} + \frac{\sigma \gamma_1}{1 - \bar{g}} + (\sigma + \eta) \frac{\partial \hat{Y}_{t+2}}{\partial(\tilde{b}_t - \tilde{D}T_t)}. \quad (\text{B.11})$$

We can therefore write

$$\begin{aligned}
\frac{\partial \tilde{b}_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} &= -\gamma_1 + \frac{1}{\beta} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} - \left(\bar{\tau} \frac{\theta - 1}{\theta} + \frac{\bar{b}}{\beta} \kappa \right) \frac{\sigma \gamma_1}{1 - \bar{g}} \\
&\quad - \left(\bar{\tau} \frac{\theta - 1}{\theta} (\sigma + \eta) + \frac{\bar{b}}{\beta} \kappa (\sigma + \eta) \right) \frac{\partial \hat{Y}_{t+2}}{\partial \tilde{b}_{t+1}} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} \\
&\quad - \left((\bar{\tau} (\sigma + \eta)) \frac{\theta - 1}{\theta} + \frac{\bar{b}}{\beta} (1 + \kappa (\sigma + \eta)) \right) \frac{\partial \hat{Y}_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} \\
&\quad + \frac{\bar{b}}{\beta} \left(1 - \beta n_{t+2}^N \kappa (\sigma + \eta) \right) \frac{\partial \hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)}.
\end{aligned} \tag{B.12}$$

In case of tax-based consolidation we get

$$\frac{\partial \hat{Y}_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} = \frac{\partial \hat{Y}_{t+2}}{\partial \tilde{b}_{t+1}} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} + n_{t+2}^N \frac{\partial \hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} - \frac{\phi_\pi - 1}{\sigma} n_{t+2}^N \frac{\partial \pi_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)}, \tag{B.13}$$

$$\frac{\partial \pi_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} = \frac{\partial \pi_{t+2}}{\partial \tilde{b}_{t+1}} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} + \frac{\kappa \gamma_2}{1 - \bar{\tau}} + \beta n_{t+2}^N \frac{\partial \pi_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} + \kappa (\sigma + \eta) \frac{\partial \hat{Y}_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)}, \tag{B.14}$$

and

$$\begin{aligned}
\frac{\partial \tilde{b}_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} &= -\frac{\theta - 1}{\theta} \gamma_2 + \frac{1}{\beta} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} - \bar{\tau} \frac{\theta - 1}{\theta} \frac{\partial \hat{m}c_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} \\
&\quad + \frac{\bar{b}}{\beta} \left(\frac{\partial \hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} - \frac{\partial \hat{Y}_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} - \frac{\partial \pi_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} \right),
\end{aligned} \tag{B.15}$$

with

$$\frac{\partial \hat{m}c_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} = \frac{\partial \hat{m}c_{t+2}}{\partial \tilde{b}_{t+1}} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} + \frac{\gamma_2}{1 - \bar{\tau}} + (\sigma + \eta) \frac{\partial \hat{Y}_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)}. \tag{B.16}$$

So that we can write

$$\begin{aligned}
\frac{\partial \tilde{b}_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} &= -\frac{\theta - 1}{\theta} \gamma_2 + \frac{1}{\beta} \frac{\partial \hat{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} - \left(\bar{\tau} \frac{\theta - 1}{\theta} + \frac{\bar{b}}{\beta} \kappa \right) \frac{\gamma_2}{1 - \bar{\tau}} \\
&\quad - \left(\bar{\tau} \frac{\theta - 1}{\theta} (\sigma + \eta) + \frac{\bar{b}}{\beta} \kappa (\sigma + \eta) \right) \frac{\partial \hat{Y}_{t+2}}{\partial \tilde{b}_{t+1}} \frac{\partial \tilde{b}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)} \\
&\quad - \left((\bar{\tau} (\sigma + \eta)) \frac{\theta - 1}{\theta} + \frac{\bar{b}}{\beta} (1 + \kappa (\sigma + \eta)) \right) \frac{\partial \hat{Y}_{t+2}}{\partial(\tilde{b}_t - \tilde{DT}_t)} \\
&\quad + \frac{\bar{b}}{\beta} \left(1 - \beta n_{t+2}^N \kappa (\sigma + \eta) \right) \frac{\partial \hat{Y}_{t+1}}{\partial(\tilde{b}_t - \tilde{DT}_t)}.
\end{aligned} \tag{B.17}$$

Subtracting the tax-based debt derivative from the spending-based debt derivative results in

$$\begin{aligned}
& -(\gamma_1 - \frac{\theta - 1}{\theta}\gamma_2) - (\bar{\tau}\frac{\theta - 1}{\theta} + \frac{\bar{b}}{\beta}\kappa)(\frac{\sigma\gamma_1}{1 - \bar{g}} - \frac{\gamma_2}{1 - \bar{\tau}}) \\
& + \left((\bar{\tau}(\sigma + \eta))\frac{\theta - 1}{\theta} + \frac{\bar{b}}{\beta}(1 + \kappa(\sigma + \eta)) \right) \frac{\gamma_1}{1 - \bar{g}}.
\end{aligned}$$

Assuming consolidations of equal impact on the budget deficit ($\gamma_1 = \frac{\theta-1}{\theta}\gamma_2$), this reduces to

$$\gamma_1 \left((\bar{\tau}\frac{\theta - 1}{\theta} + \frac{\bar{b}}{\beta}\kappa) \left(\frac{\theta}{(\theta - 1)(1 - \bar{\tau})} + \frac{\eta}{1 - \bar{g}} \right) + \frac{\bar{b}}{\beta} \frac{1}{1 - \bar{g}} \right). \quad (\text{B.18})$$

This implies that a spending-based consolidation leads to a higher debt than a tax-based consolidation after two periods. Substituting for steady state debt we get

$$\gamma_1 \left((\bar{\tau}\frac{\theta - 1}{\theta} + \frac{\bar{\tau}\frac{\theta-1}{\theta} - \bar{g}}{1 - \beta}\kappa) \left(\frac{\theta}{(\theta - 1)(1 - \bar{\tau})} + \frac{\eta}{1 - \bar{g}} \right) + \frac{\bar{\tau}\frac{\theta-1}{\theta} - \bar{g}}{1 - \beta} \frac{1}{1 - \bar{g}} \right). \quad (\text{B.19})$$

B.3 Proof Proposition 3

We assume steady state levels and we assume a spending-based consolidation is implemented. In a fixed point where Fundamentalists have correctly updated their belief to $\alpha_t = 1$ inflation and output satisfy

$$\pi(1 - \beta n^N) = \kappa(\sigma + \eta)Y + \kappa\sigma \frac{\gamma_1(b - DT)}{1 - \bar{g}}, \quad (\text{B.20})$$

$$(1 - n_t^N)Y = -(1 - n_t^N) \frac{1}{\eta + \sigma} \sigma \frac{\gamma_1(b - DT)}{1 - \bar{g}} - \frac{\phi_\pi - 1}{\sigma} n_t^N \pi. \quad (\text{B.21})$$

Solving this two equations shows that fixed point inflation and marginal cost are zero and fixed point output is given by the Fundamentalists expected value:

$$Y = -\frac{1}{\eta + \sigma} \sigma \frac{\gamma_1(b - DT)}{1 - \bar{g}}. \quad (\text{B.22})$$

For debt we have in the fixed point where marginal cost and inflation are zero:

$$b = -\gamma_1(b - DT) + \frac{1}{\beta}b. \quad (\text{B.23})$$

The fixed point debt ratio therefore is

$$b = \frac{DT\gamma_1}{1 - \frac{1}{\beta} + \gamma_1}. \quad (\text{B.24})$$

This is indeed a fixed point when the fixed point debt ratio lies above the debt threshold. This is the case if and only if

$$\gamma_1 > \frac{1}{\beta} - 1. \quad (\text{B.25})$$

B.4 Proof Proposition 4

In tax case of tax-based consolidations that are fully expected by Fundamentalists ($\alpha_t = 0$) we again have a fixed point where marginal cost and inflation are zero. Output is now given by

$$Y = -\frac{1}{\eta + \sigma} \left(\frac{\gamma_2(b - DT)}{1 - \bar{\tau}} \right).$$

For debt we now have

$$b = \frac{DT\gamma_2 \frac{\theta-1}{\theta}}{1 - \frac{1}{\beta} + \gamma_2 \frac{\theta-1}{\theta}}. \quad (\text{B.26})$$

This is indeed a fixed point when this debt ratio lies above the debt threshold

The condition now becomes

$$\gamma_2 \frac{\theta - 1}{\theta} > \frac{1}{\beta} - 1. \quad (\text{B.27})$$

C Robustness

C.1 Largest eigenvalues

In this section, we look at the robustness of the largest eigenvalue results of Section 4.3 to the chosen parametrization. In Figure 10, we plot the case of weaker monetary policy, where $\phi_\pi = 1.1$ instead of $\phi_\pi = 1.5$. This figure looks very similar to Figure 1, so monetary policy does not seem to have a big impact on dynamics. This is because agents are short-sighted, heterogeneous and form expectations for one period ahead only. As such, changes in the commitment of the central bank to a specific rule have a smaller effect on expectations and thereby on the dynamics of the model. In Bi et al. (2013) instead, agents forecast over an infinite horizon and there is no heterogeneity in expectations. There, a less active monetary policy makes tax increases more expansionary after the consolidation, while it makes spending cuts much more contractionary.

In Figure 11, we plot the case where price adjustment costs are equal to $\phi = 10$ rather than $\phi = 100$. This leads to a much flatter Phillips curve. Similarly, Figure 12 plots the case where the relative risk aversion parameter is $\sigma = 0.157$ instead of $\sigma = 2$.

In both Figures, qualitative results for reasonable values of γ_1 are the same as in Section 4.3. That is, for low values of γ_1 slow monotonic convergence occurs for both spending and tax-based

consolidations due to a large positive eigenvalue. As γ_1 decreases, the eigenvalue becomes smaller and eventually the largest eigenvalues are complex.

C.2 Stronger consolidations

In this section, we consider what happens to our benchmark impulse responses of Section 5.1 when the government implements stronger consolidations. We now set $\gamma_1 = 0.5$ instead of $\gamma_1 = 0.2$. Results of the benchmark case of anticipated consolidations with no composition uncertainty are presented in Figure 13 and 14 for respectively spending-based and tax-based consolidations.

In Figure 13 we see that debt overshoots both its fixed point value and the debt threshold in period 5. This is in line with the finding of Section 4.3 that the largest eigenvalue now is complex. Even though the debt ratio is eventually reduced faster and to a lower level, debt could considerably increase in the first period of implementation if all agents are initially Naive (red curves). The intuition for the larger difference between the 3 specifications of our behavioral model is that the stronger consolidations magnify expectation effects caused by Naive and Fundamentalists, both prior and during the consolidations. Furthermore, in the top left panel, it can be seen that the contraction in output is deeper due to the stronger spending cuts.

	1qr	4qr	8qr	12qr
$\frac{\Delta Y}{\Delta G}$	-0.74	-0.72	-0.74	-0.75
$\frac{\Delta Y}{\Delta \tau}$	-0.33	-0.31	-0.32	-0.32

Table 5: Output multipliers in case of stronger consolidations with $\gamma_1 = 0.5$ instead of 0.2.

We present the multipliers in Table 5. First focusing on spending-based consolidations and comparing with panel (a) of Table 2, it can be seen that even though, stronger spending-based consolidations are more successful in reducing debt, they lead to more negative multipliers. On the other hand, stronger tax-based consolidations only lead to a more negative impact multiplier, but to less negative long run multipliers. In Figure 14 we plot the case of correctly anticipated stronger tax-based consolidations. Again, the differences between the three specifications of initial conditions are amplified compared to the case of weaker consolidations, with the possibility of a significantly larger recession. However, debt is reduced faster and to a level significantly below the debt level. Finally, we can conclude that also under stronger consolidations, tax-based consolidations are more effective in reducing debt, and lead to less negative multipliers.

C.3 Implementation lag

Throughout the paper, we have assumed that fiscal adjustments take one period to be implemented. That is, in period t the government compares that last observed debt ratio (\tilde{b}_{t-1}) with the debt threshold ($\tilde{D}T_{t-1}$) and based on this determines next periods government spending and taxes (\tilde{g}_{t+1} and $\tilde{\tau}_{t+1}$). In this appendix we study robustness to this specification, by considering what would happen if the government did not have such an implementation lag, so that decides in period t on government spending and taxes of period t (\tilde{g}_t and $\tilde{\tau}_t$). We keep however the assumption that endogenous variables are not observed contemporaneously, so that this period t decision is based on information up to period $t - 1$. The fiscal rules then become

$$\tilde{g}_t = -\zeta\gamma_1 \max(0, \tilde{b}_{t-1} - \tilde{D}T_{t-1}), \quad (\text{C.1})$$

and

$$\tilde{\tau}_t = (1 - \zeta)\gamma_2 \max(0, \tilde{b}_{t-1} - \tilde{D}T_{t-1}). \quad (\text{C.2})$$

This implies that \tilde{g}_{t+1} and $\tilde{\tau}_{t+1}$ will depend on \tilde{b}_t . Since fundamentalists need to form expectations about \tilde{g}_{t+1} and $\tilde{\tau}_{t+1}$ in period t , when \tilde{b}_t is not observed yet, it becomes slightly harder for them to correctly anticipate consolidations. However, since fundamentalists form expectations by assuming a fixed point where debt remains constant (making use of the high persistence in this variable) we assume that they also do this here and approximate the current debt ratio by $\tilde{b}_t \approx \tilde{b}_{t-1}$. Since Fundamentalists do observe the exogenously announced debt threshold contemporaneously, their expectations then satisfy

$$E_t^F \tilde{g}_{t+1} = -\alpha_t\gamma_1 \max(0, \tilde{b}_{t-1} - \tilde{D}T_t). \quad (\text{C.3})$$

$$E_t^F \tilde{\tau}_{t+1} = (1 - \alpha_t)\gamma_2 \max(0, \tilde{b}_{t-1} - \tilde{D}T_t). \quad (\text{C.4})$$

In Figures 15 and 16 we plot the impulse responses of our behavioral model for the benchmark cases of correctly anticipated spending-based and tax-based consolidations, respectively. Comparing these Figures with 2 and 3, it can be seen that without the implementation lag, dynamics are slightly more monotonic. In case of tax-based consolidations, it can further be seen that the largest tax hikes now take place in the first period of implemented consolidations (period 2), rather than on

period later (it is period 3 in Figure 3). This is because the highest debt level is still reached in the anticipation period (period 1), and without an implementation lag the period where taxes are based on this debt level is now period 2, rather than period 3.

Overall, however, the dynamics in Figures 15 and 16 are qualitatively very similar to those of figures 2 and 3, and our main results are robust to the assumption of a fiscal implementation lag.

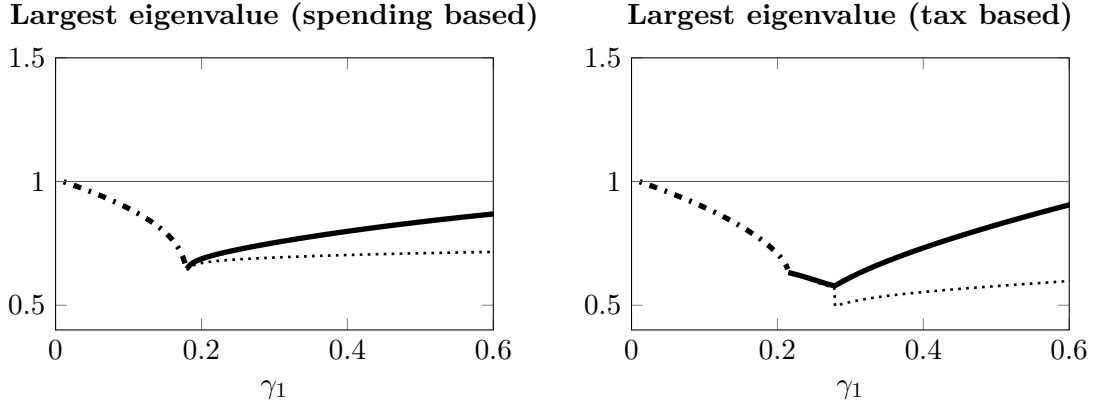


Figure 10: Absolute values of largest eigenvalue in high debt fixed point for spending and tax-based consolidations. The dashed-dotted segment depicts a real and positive eigenvalue, while a solid segment depicts complex eigenvalues. The real part of the complex eigenvalues is plotted as a dotted curve. In case of tax-based consolidations it holds that $\gamma_2 = \frac{\theta}{\theta-1}\gamma_1$. In the Figure, the benchmark calibration is used, but with $\phi_\pi = 1.1$ instead of $\phi_\pi = 1.5$.

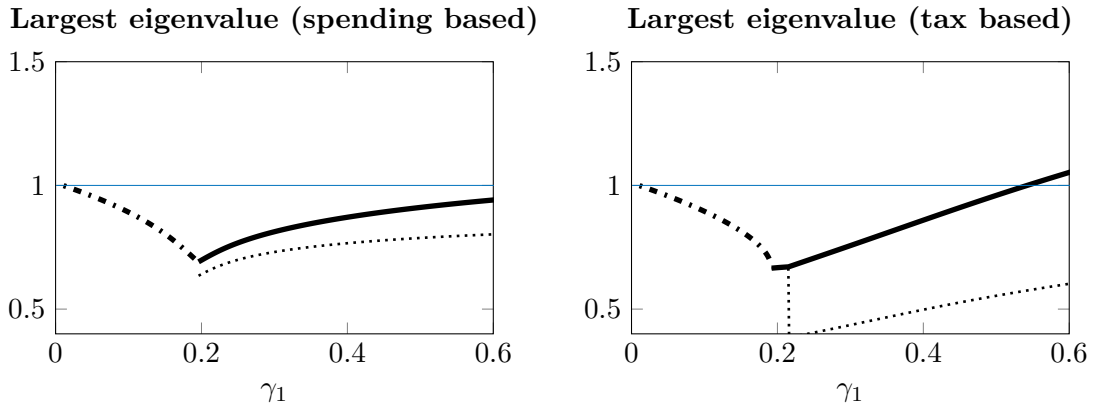


Figure 11: Absolute values of largest eigenvalue in high debt fixed point for spending and tax-based consolidations. The dashed-dotted segment depicts a real and positive eigenvalue, while a solid segment depicts complex eigenvalues. The real part of the complex eigenvalues is plotted as a dotted curve. In case of tax-based consolidations it holds that $\gamma_2 = \frac{\theta}{\theta-1}\gamma_1$. In the Figure, the benchmark calibration is used, but with $\phi = 10$ instead of $\phi = 100$.

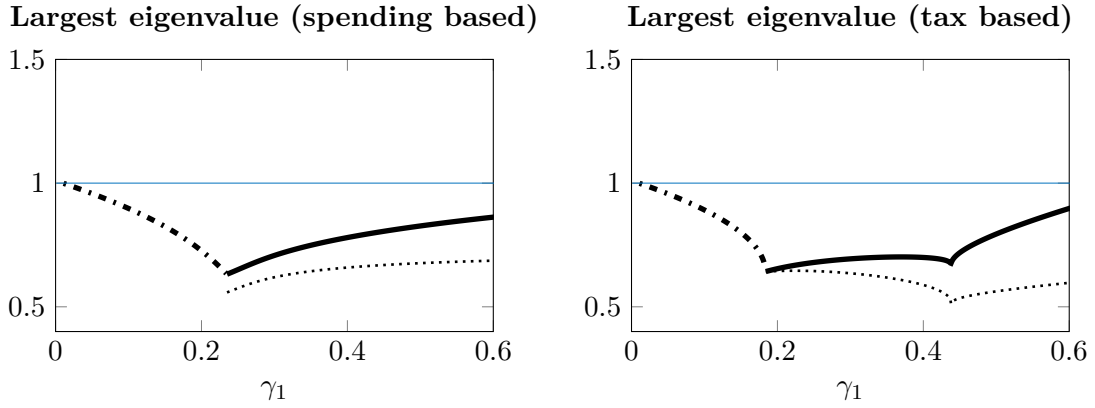


Figure 12: Absolute values of largest eigenvalue in high debt fixed point for spending and tax-based consolidations. The dashed-dotted segment depicts a real and positive eigenvalue, while a solid segment depicts complex eigenvalues. The real part of the complex eigenvalues is plotted as a dotted curve. In case of tax-based consolidations it holds that $\gamma_2 = \frac{\theta}{\theta-1}\gamma_1$. In the Figure, the benchmark calibration is used, but with $\sigma = 0.157$ instead of $\sigma = 2$.

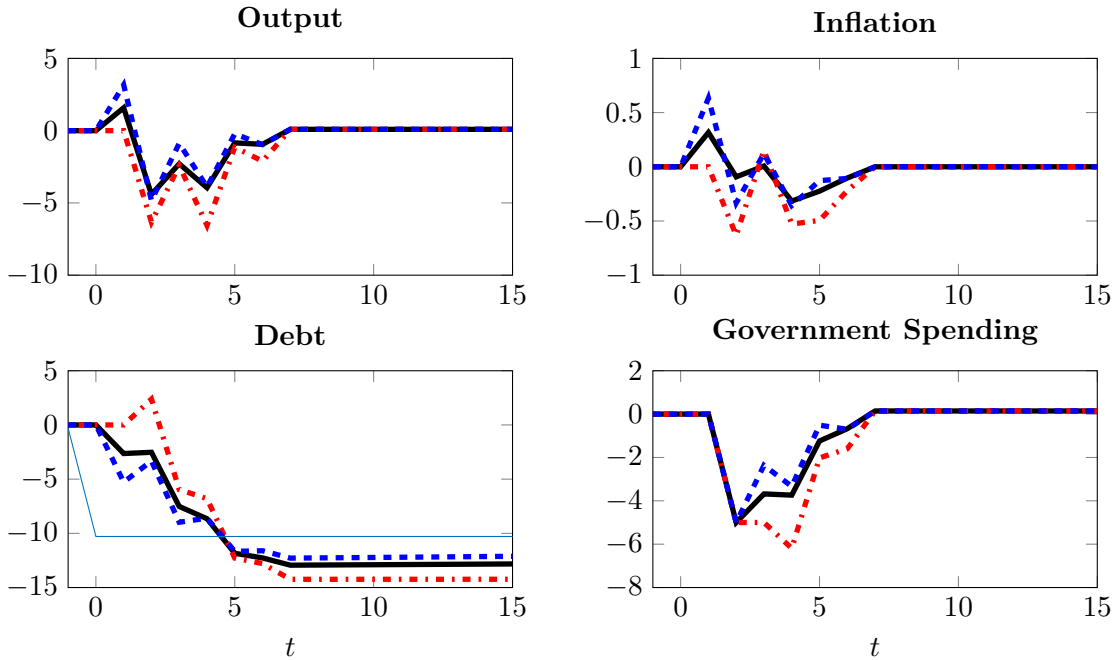


Figure 13: Impulse responses to debt threshold shock for correctly anticipated spending-based consolidations. In the Figure $\gamma_1 = 0.5$ instead of 0.2. The benchmark behavioral model is plotted in black, and the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive. The debt threshold is plotted in blue in the bottom left panel.

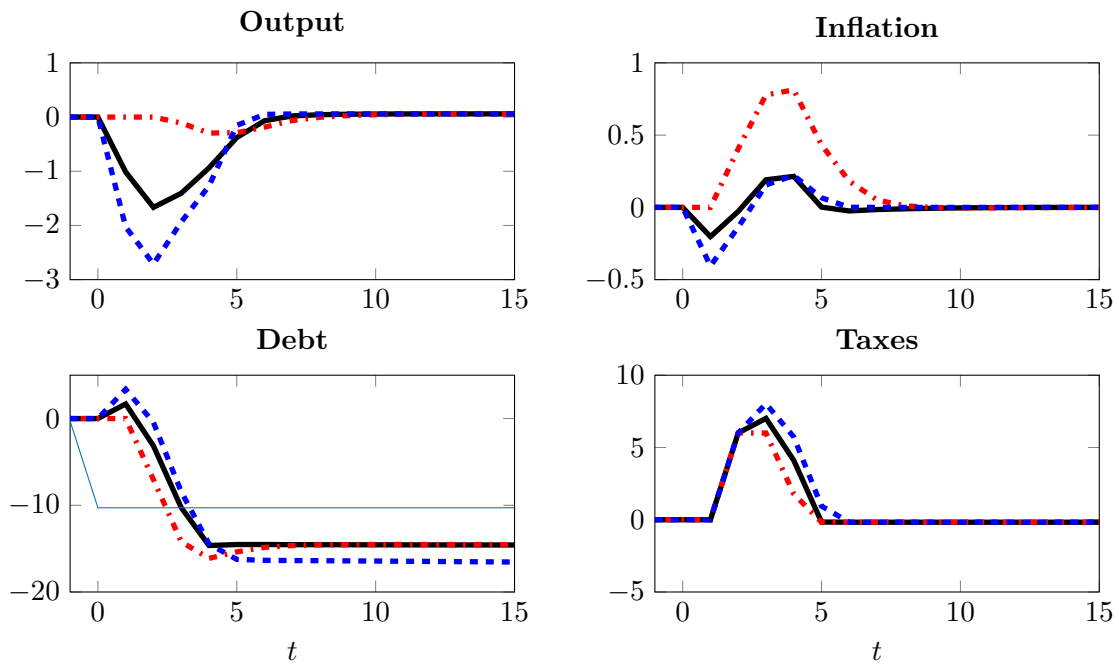


Figure 14: Impulse responses to debt threshold shock for correctly anticipated strong tax-based consolidations. In the Figure $\gamma_1 = 0.5$ instead of 0.2. The benchmark behavioral model is plotted in black, and the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive. The debt threshold is plotted in blue in the bottom left panel.

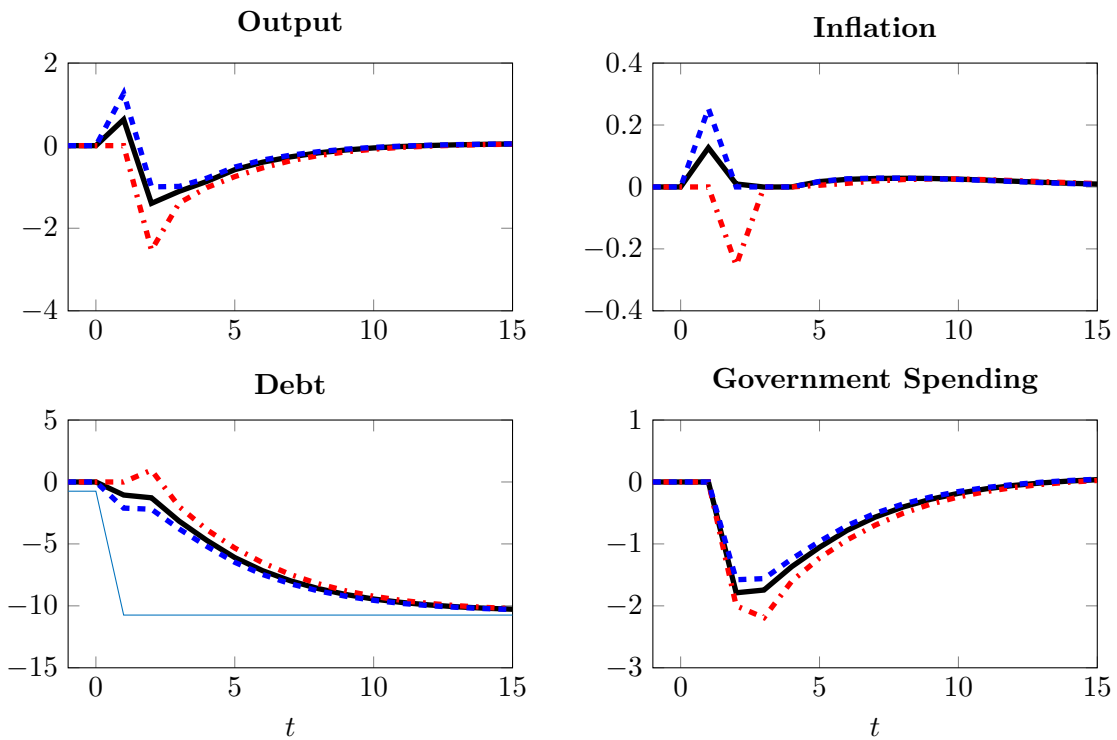


Figure 15: Impulse responses to debt threshold shock for correctly anticipated spending-based consolidations in case of no implementation lag for fiscal adjustments. The benchmark behavioral model is plotted in black, and the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive. The debt threshold is plotted in blue in the bottom left panel.

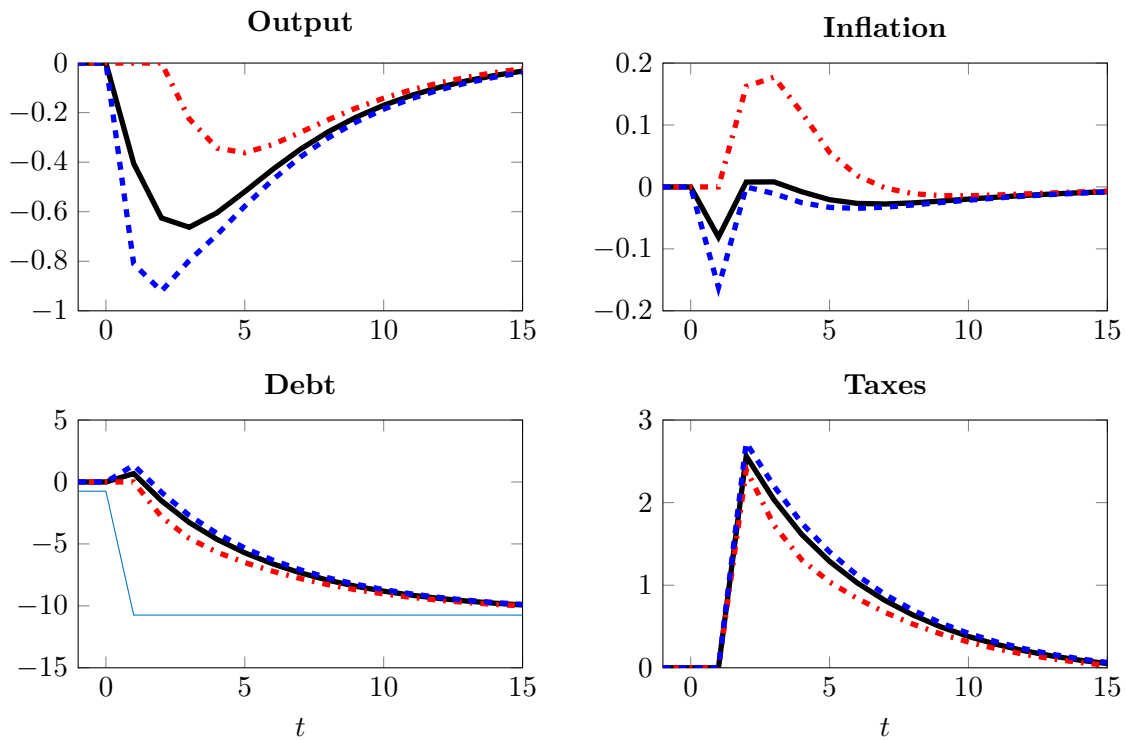


Figure 16: Impulse responses to debt threshold shock for correctly anticipated tax-based consolidations in case of no implementation lag for fiscal adjustments. The benchmark behavioral model is plotted in black, and the dashed blue and dashed-dotted red curves depict the cases where in the initial fixed point all agents were respectively Fundamentalists and Naive. The debt threshold is plotted in blue in the bottom left panel.

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