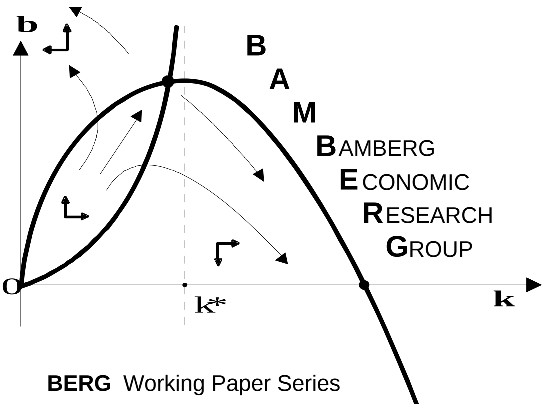
This research was carried out in the Bamberg Doctoral Research Group on Behavioral Macroeconomics (BaGBeM) supported by the Hans-Böckler Foundation (PK 045)

Fiscal Stimulus in an Expectation Driven Liquidity Trap

Joep Lustenhouwer

Working Paper No. 138

September 2018



Bamberg Economic Research Group
Bamberg University
Feldkirchenstraße 21
D-96052 Bamberg
Telefax: (0951) 863 5547
Telephone: (0951) 863 2687
felix.stuebben@uni-bamberg.de
http://www.uni-bamberg.de/vwl/forschung/berg/

ISBN 978-3-943153-59-0

Redaktion:
Dr. Felix Stübben*

* felix.stuebben@uni-bamberg.de

Fiscal Stimulus in an Expectation Driven Liquidity Trap

Joep Lustenhouwer*[a]

[a]Otto-Friedrich-Universität Bamberg

Abstract

I study expectation driven liquidity traps in a model were agents have finite planning horizons and heterogeneous expectations. There are backward-looking agents, who base their expectations on past observations, and forward-looking agents, who observe the expectations of backward-looking agents, and use model equations within their planning horizon to make forecasts. Expectation driven liquidity traps arise when the presence of backward-looking agents leads to a wave of pessimism after a single, non-persistent, negative preference shock. I find that fiscal stimulus in the form of an increase in government spending or a cut in consumption taxes can be very effective in mitigating the liquidity trap. Moreover, an adequate response of these measures is found to always be able to prevent deflationary spirals, that can arise when there is a large fraction of backward-looking agents with a longer planning horizon. A positive inflation target furthermore reduces the fiscal stimulus required to resolve a liquidity trap for any given size of the negative preference shock. In contrast, fiscal stimulus in the form of labor tax cuts is deflationary and hardly effective in mitigating liquidity traps.

*Email address: joep.lustenhouwer@uni-bamberg.de

1 Introduction

Can fiscal stimulus be used to escape a liquidity trap? Several studies have found that in a liquidity trap, where the zero lower bound is binding and real interest rates fall when inflation is increased, government spending multipliers are higher than in normal times (among others Christiano et al., 2009, Eggertsson, 2011 and Woodford, 2011). This implies that a government spending stimulus could be used to increase inflation and output, which might get the economy out of the liquidity trap. Erceg and Lindé (2014) find that fiscal stimulus can indeed be used to shorten liquidity traps and even resolve them immediately if the stimulus is large enough. A stimulus in labor taxes on the other hand will be less effective, because this measure not just increases output, but also increases labor supply, implying lower wages. The resulting decrease in marginal costs for firms puts downward pressure on inflation which negativity impacts the severity and possibly the duration of the liquidity trap.

These results are reversed in a study by Mertens and Ravn (2014), who investigate the interesting possibility that a liquidity trap is not driven purely by fundamental shocks, such as persistent shock to the household's discount factor, but instead by expectations. In their model such an expectation driven liquidity trap takes the form of a sunspot equilibrium. They find that contrary to widely held views, in their setup, increasing government spending at the zero lower bound is deflationary in equilibrium and is not very effective in mitigating a liquidity trap, while cutting labor taxes is inflationary in equilibrium and does mitigate the liquidity trap considerably.

In this paper, I model expectation driven liquidity traps in a framework of bounded rationality, rather than with a sunspot equilibrium. I find that in line with the literature on liquidity traps driven by fundamentals, in my liquidity traps driven by boundedly rational expectations, government spending increases are inflationary and hence effective in mitigating a liquidity trap while labor tax cuts are deflationary and less effective. This shows that the reversal of traditional results that was found by Mertens and Ravn (2014) is not a general feature of liquidity traps driven by expectations, but depends crucially on the choice of modeling an expectation driven liquidity trap as a sunspot equilibrium.

Assuming a sunspot equilibrium stays relatively close to the rational expectations benchmark, and furthermore assumes that all agents in the economy form the same expectations. These features may not be fully realistic when considering a liquidity trap that is driven by expectations. In this paper instead, I allow for more bounded rationality in expectation formation and decision making, and furthermore for heterogeneity in expectations. First of all, there are two types of agents: forward-looking agents and backward-looking agents. Forward-looking agents form expectations in a forward-looking manner, using their knowledge of the model equations. Backward-looking agents on the other hand, base their expectations on recent observations and assume that all variables will mean-revert back to their steady state in the future, with some auto-regressive coefficient. These backward-looking expectations represent participants of the economy that use simple rules of thumps, based on what they are currently observing in the economy. Such rule of thumb behavior is found to be consistent with expectations of human subjects in laboratory experiments (see e.g. Assenza et al. (2014) and Pfajfar and Zakelj, 2011) as well as with survey data (see e.g. Branch (2004, 2007)). This particular form of backward-looking expectations is used by e.g. Branch and McGough (2010) and Gasteiger (2014), who label it adaptive expectations. Secondly, all agents in my model have a finite planning horizon as in Lustenhouwer and Mavromatis (2017). Instead of being able to form expectations up to an infinite horizon, and basing their decisions on these expectations, agents are relatively short-sighted and are not able to plan ahead and form expectations more than T periods into the future. Their optimization problems are therefore adjusted accordingly.

In this setup of bounded rationality, I study in detail how expectation driven liquidity traps can arise and how this depends on the fraction of backward-looking agents in the economy and on agents' planning horizon. I compare such a liquidity trap, with a liquidity trap driven by a persistent fundamental shock. Interestingly, I find that when agents have planning horizons that are not too long, expectation driven liquidity traps of considerable duration can arise, from which the economy eventually recovers. If on the other hand, agents have a long or infinite planning horizon, an expectation driven liquidity trap either is of only limited duration, or results in a deflationary spiral from which the economy does not by itself recover.

I then turn to the question whether fiscal stimulus in the form of a spending increase or tax-cut can mitigate the severity and duration of expectation driven liquidity traps and prevent deflationary spirals. As mentioned above, I find that an increase in government spending is effective in mitigating a liquidity trap, while cutting labor taxes has only very mild positive effects. In addition, I also consider cutting consumption taxes. Unlike a cut in labor taxes, I find that a cut in consumption taxes is inflationary and can considerably reduce the duration of a liquidity trap. Moreover, I find that both increases in government spending and cuts in consumption taxes can prevent deflationary spirals that arise for large planning horizons, while cuts in labor taxes cannot. Finally, I find in an extension of the model that the required size of fiscal stimulus to prevent a deflationary spiral can considerably be reduced if the central bank has a higher inflation target.

My findings regarding the effects of government spending increases in a liquidity trap are in line with those of Hommes et al. (2015) and a series of papers by Evans and coauthors (Evans et al., 2008, Evans and Honkapohja (2009), Benhabib et al., 2014). Hommes et al. (2015) conduct a laboratory experiment, where rather than making any assumptions on agent's expectations, they let expectations be formed by human subjects in the laboratory. They are able to initiate an expectation driven liquidity trap by either initializing the economy with low historical data for inflation and output gap, or by later showing subjects pessimistic newspaper opinions. Without fiscal intervention, deflationary spirals regularly occur in their experiment. However, in treatments where there is a fiscal switching rule and government spending is increased when inflation is below some threshold deflationary spirals are always prevented. These confirms the results of Evans et al., 2008, Evans and Honkapohja (2009) and Benhabib et al., 2014, who find that under adaptive learning such spending increases can always prevent deflationary spirals that would otherwise have arisen because of the zero lower bound. These papers however, do not consider the effectiveness labor or consumption tax cuts. Mertens and Ravn (2014) also do not consider the latter.

To the best of my knowledge this paper therefore is the first to investigate the effectiveness of consumption tax cuts in an expectation driven liquidity trap. Eggertsson (2011), Coenen et al. (2012) and Correia et al. (2013) find that this instrument can be quite effective in a liquidity trap driven by fundamentals.

The modeling approach with fractions of forward and backward-looking agents is closely related to Gasteiger (2014, 2017), Branch and McGough (2009) and Elton et al. (2017), as well as to Massaro (2013) and Deák et al. (2017). The framework used to model finite horizons is similar to that of Branch et al. (2010) and Woodford (2018). See Lustenhouwer and Mavromatis (2017) for a detailed discussion of the differences with these frameworks. This paper is the first to combine such a micro-founded framework of finite planning horizons with heterogeneity in expectations.

The remainder of the paper is organized as follows. In Section 2, the model and expectation formation processes are outlined. In Section 3, I present how expectation driven liquidity traps can occur, and how their duration depends on the behavioral features of the model. In Section 4, the effectiveness of different fiscal stimulus packages is investigated. Finally, Section 5 concludes.

2 Model

The model is made up by a continuum of households $i \in [0, 1]$, a continuum of firms $j \in [0, 1]$ and a monetary and fiscal authority. Moreover, there are two types of households and firms. A fraction α of households and firms forms expectations in a backward-looking manner and a fraction $1 - \alpha$ forms expectations in a forward-looking manner. The expectations of these two types of households and firms will be specified in Section 2.5.

2.1 Households

Households want to maximize their discounted utility over their planning horizon (T periods), and they also value the state they expect to end up in at the end of these T periods (their state in period T+1). They are not able rationally induce (by solving the model forward), how exactly they should value their state in period T+1. Instead households use a rule of thumb to evaluate the value of their state (their wealth). As in Lustenhouwer and Mavromatis (2017), their objective function therefore exists of a sum of utility, U(), out of consumption and leisure for the periods within their horizon, as well as an extra term with a function V() that is increasing in end of horizon wealth.

$$\max_{C_\tau^i, H_\tau^i, B_\tau^i} \tilde{E}_t^i \sum_{s=t}^{t+T} \beta^{s-t} \xi_s u(C_s^i, H_s^i) + \beta^{T+1} \xi_{t+T+1} V(\frac{B_{t+T+1}^i}{P_{t+T}}), \tag{1}$$

subject to

$$(1+\tau_\tau^c) P_\tau C_\tau^i + \frac{B_{\tau+1}^i}{1+i_\tau} \le (1-\tau_\tau^l) W_\tau H_\tau^i + B_\tau^i + P_\tau \Xi_\tau, \qquad \tau = t, t+1, ...t+T \tag{2}$$

where B_t^i are nominal bond holdings from household i at the beginning of period t; C_τ^i and H_τ^i are the household's consumption and labor; Ξ_t are real profits from firms which are equally distributed among households; τ_τ^c and τ_τ^l are respectively the consumption tax and labor tax rates; i_τ is the nominal interest rate; P_τ is the price level; and W_t is the nominal wage rate. Finally β is the household's discount factor, while ξ_τ is an exogenous preference shock.

Furthermore, it is assumed that households have CRRA preferences both for consumption and labor and for wealth at the end of their horizon. Moreover, the relative utility of real bond holdings in a given period compared to consumption in that period is be given by Λ. The functional form of $V(.)$ therefore becomes

$$V(x) = \Lambda \frac{x^{1-\sigma}}{1-\sigma}. \tag{3}$$

Dividing the budget constraint by P_τ gives

$$(1+\tau_\tau^c) C_\tau^i + \frac{B_{\tau+1}^i}{(1+i_\tau) P_\tau} \le (1-\tau_\tau^l) w_\tau H_\tau^i + \frac{B_\tau^i}{P_\tau} + \Xi_\tau, \qquad \tau = t, t+1, ...t+T \tag{4}$$

The first order conditions of the maximization problem are

$$\xi_\tau (C^i_\tau)^{-\sigma} = \lambda^i_\tau (1+\tau^c_\tau), \qquad \tau = t, t+1, ...t+T \tag{5}$$

$$(H^i_\tau)^\eta = \lambda^i_\tau (1-\tau^l_\tau) w_\tau, \qquad \tau = t, t+1, ...t+T \tag{6}$$

$$\lambda^i_\tau = \beta \frac{(1+i_\tau)\lambda^i_{\tau+1}}{\Pi_{\tau+1}}, \qquad \tau = t, t+1, ...t+T-1 \tag{7}$$

$$\lambda^i_{t+T} = \beta \xi_{t+T+1}(1+i_{t+T})(\frac{B^i_{t+T+1}}{P_{t+T}})^{-\sigma}\Lambda, \tag{8}$$

Next we define a measure of real bond holdings, scaled by steady state output: $b_t = \frac{B_t}{P_{t-1}\bar{Y}}$. Substituting for this expression in (8) and (4) gives

$$\lambda^i_{t+T} = \beta \xi_{t+T+1}(1+i_{t+T})(\bar{Y} b^i_{t+T+1})^{-\sigma}\Lambda, \tag{9}$$

and

$$(1+\tau^c_\tau)C^i_\tau + \bar{Y}\frac{b^i_{\tau+1}}{1+i_\tau} \leq (1-\tau^l_t) w_\tau H^i_\tau + \frac{\bar{Y} b^i_\tau}{\Pi_\tau} + \Xi_\tau, \qquad \tau = t, t+1, ...t+T \tag{10}$$

2.2 Firms

There is a continuum of firms producing the final differentiated goods. There is monopolistic competition and each firm is run by a household and follows the same heuristic for prediction of future variables as that household in each period.

Each firm has a linear technology with labor as its only input

$$Y_t(j) = H_t(j), \tag{11}$$

Since firms are owned by households, they will be short sighted. That is, they will form expectations about their marginal costs and the demand for their product for T periods ahead only. We assume that in each period a fraction $(1-\omega)$ firms can change their price, as in Calvo (1983). The problem of firm j that can reset its price is then to maximize the discounted value of its profits for the next T periods.

$$\tilde{E}_t^j \sum_{s=0}^{T} \omega^s Q_{t,t+s}^j \Big[p_t(j) Y_{t+s}(j) - P_{t+s} mc_{t+s} Y_{t+s}(j) \Big], \tag{12}$$

where

$$Q_{t,t+s}^j = \beta^s \frac{\xi_{t+s}}{\xi_t} \frac{1+\tau_t^c}{1+\tau_{t+s}^c} \left(\frac{C_{t+s}^j}{C_t^j} \right)^{-\sigma} \frac{P_t}{P_{t+s}}. \tag{13}$$

is the stochastic discount factor of the household (j) that runs firm j.

Using the demand for good j, the firm's profits maximization problem writes as follows

$$\max \tilde{E}_t^j \sum_{s=0}^{T} \omega^s \beta^s \frac{\xi_{t+s}}{\xi_t} \frac{1+\tau_t^c}{1+\tau_{t+s}^c} \left(\frac{C_{t+s}^j}{C_t^j} \right)^{-\sigma} P_t \Bigg[\left(\frac{p_t(j)}{P_{t+s}} \right)^{1-\theta} Y_{t+s} - mc_{t+s} \left(\frac{p_t(j)}{P_{t+s}} \right)^{-\theta} Y_{t+s} \Bigg]. \tag{14}$$

The first order condition for $p_t(j)$ is

$$\tilde{E}_t^j \sum_{s=0}^{T} \omega^s \beta^s \frac{\xi_{t+s}}{\xi_t} \frac{1+\tau_t^c}{1+\tau_{t+s}^c} \left(\frac{C_{t+s}^j}{C_t^j} \right)^{-\sigma} \frac{P_t}{P_{t+s}} Y_{t+s} \Bigg[(1-\theta) \left(\frac{p_t^*(j)}{P_{t+s}} \right)^{-\theta} + \theta mc_{t+s} \left(\frac{p_t^*(j)}{P_{t+s}} \right)^{-1-\theta} \Bigg] = 0, \tag{15}$$

where $p_t^*(j)$ is the optimal price for firm j if it can re-optimize in period t.

Next, turn to the evolution of the aggregate price level. I assume that the set of firms that can change their price in a period is chosen independently of the type of the household running the firm, so that the distribution of expectations of firms that can change their price is identical to the distribution of expectations of all firms. Since decisions of firms only differ in so far their expectations differ, it follows that the aggregate price level evolves as

$$P_t = [\omega P_{t-1}^{1-\theta} + (1-\omega) \int_0^1 p_t^*(j)^{1-\theta} \mathrm{d}j]^{\frac{1}{1-\theta}}, \tag{16}$$

This can, after dividing by P_t, be written as

$$1 = \omega \Pi_t^{\theta-1} + (1-\omega) \int_0^1 d_t(j)^{1-\theta} \mathrm{d}j, \tag{17}$$

2.3 Government and market clearing

The government issues bonds and levies labor taxes (τ_t^l) and consumption taxes (τ_t^c) to finance its (wasteful) spending (G_t). Its budget constraint is given by

$$\frac{B_{t+1}}{1+i_t} = P_t G_t - \tau_t^l W_t H_t - \tau_t^c P_t C_t + B_t, \tag{18}$$

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 $\bar{Y} P_t$ gives

$$\frac{b_{t+1}}{1+i_t} = g_t - \tau_t^l w_t \frac{H_t}{\bar{Y}} + \tau_t^c \frac{C_t}{\bar{Y}} + \frac{b_t}{\Pi_t}, \tag{19}$$

where $b_t = \frac{B_t}{P_{t-1}\bar{Y}}$ and $g_t = \frac{G_t}{\bar{Y}}$ are the ratios of debt to steady state GDP and government expenditure to steady state GDP, respectively.

Market clearing is given by

$$Y_t = C_t + G_t = C_t + \bar{Y} g_t \tag{20}$$

Fiscal policy is given by

$$g_t = DS_t, \tag{21}$$

and

$$\tau_t^l = DLT_t - \gamma(b_t - \bar{b}), \tag{22}$$

$$\tau_t^c = DCT_t, \tag{23}$$

where DS_t is a time varying component of discretionary spending, and DLT_t and DLT_t are time varying components of discretionary labor and consumption taxes respectively.

These variables will be used below to model discretionary fiscal stimulus. Additionally, labor taxes stabilize the debt ratio with a coefficient of γ.

The monetary policy rule is given by

$$1 + i_t = \max\left(1, (1+\bar{i})\left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\phi_1}\left(\frac{Y_t}{\bar{Y}}\right)^{\phi_2}\right) \tag{24}$$

2.4 Linearized model

In Appendix B the model is linearized around a general inflation target, and the resulting model equations are given by Equations (78) through (95) in that appendix. In most of the paper I assume a zero inflation target, and only in Section 4.3 I focus on the effects of changing the inflation target to a positive value. When the inflation target is 0, the linearized model equations reduce to

$$\begin{aligned}(1-\nu_{y0})\hat{Y}_t = {} & \frac{1}{\rho_0}\tilde{b}_t + g_t + \nu_{\tau 0}\sum_{s=0}^{T}\beta^s(\bar{E}_t\hat{\tau}^l_{t+s}) + \nu_{g0}\sum_{s=0}^{T}\beta^s(\bar{E}_t\hat{g}_{t+s}) + \nu_{y0}\sum_{s=1}^{T}\beta^s(\bar{E}_t\hat{Y}_{t+s}) \\ & - \mu_0\sum_{s=1}^{T}\beta^s\sum_{j=1}^{s}(\bar{E}_t i_{t+j-1} - \bar{E}_t\hat{\pi}_{t+j}) + \frac{\bar{b}}{\rho_0}\sum_{s=0}^{T}\beta^s(\beta\bar{E}_t\hat{i}_{t+s} - \bar{E}_t\hat{\pi}_{t+s}) \\ & - \beta^{T+1}\frac{\bar{b}}{\sigma\rho_0}\sum_{j=0}^{T-1}(\bar{E}_t i_{t+j} - \bar{E}_t\hat{\pi}_{t+j+1}) - \beta^{T+1}\frac{\bar{b}}{\sigma\rho_0}\bar{E}_t i_{t+T} \\ & + \delta_{\xi 0}\xi_t + \nu_{\xi 0}\sum_{s=0}^{T}\beta^s\bar{E}_t\tilde{\xi}_{t+s} - \mu_{\xi 0}\sum_{s=1}^{T}\beta^s(\bar{E}_t\xi_{t+s} - \xi_t) - \beta^{T+1}\frac{\bar{b}}{\sigma\rho_0}(\bar{E}_t\xi_{t+T+1} - \bar{E}_t\xi_{t+T}) \\ & - \frac{\delta_{\xi 0}}{1+\bar{\tau}^c}\tilde{\tau}^c_t + \nu_{c0}\sum_{s=0}^{T}\beta^s\bar{E}_t\tilde{\tau}^c_{t+s} + \frac{(1-\bar{g})}{\rho_0\sigma}\sum_{s=1}^{T}\beta^s(\bar{E}_t\tilde{\tau}^c_{t+s} - \bar{E}_t\tilde{\tau}^c_t) - \beta^{T+1}\frac{\bar{b}}{\sigma\rho}\frac{\bar{E}_t\tilde{\tau}^c_{t+T}}{1+\bar{\tau}^c}\end{aligned} \tag{25}$$

$$\hat{\pi}_t = \tilde{\kappa}(\eta + \frac{\sigma}{1-\bar{g}}) \sum_{s=0}^{T} \omega^s \beta^s \hat{E}_t \hat{Y}_{t+s} - \frac{\tilde{\kappa}\sigma}{1-\bar{g}} \sum_{s=0}^{T} \omega^s \beta^s \hat{E}_t \tilde{g}_{t+s}$$
$$+ \frac{\tilde{\kappa}}{1+\bar{\tau}^c} \sum_{s=0}^{T} \omega^s \beta^s \hat{E}_t \tilde{\tau}^c_{t+s} + \frac{\tilde{\kappa}}{1-\bar{\tau}^l} \sum_{s=0}^{T} \omega^s \beta^s \hat{E}_t \tilde{\tau}^l_{t+s} + \tilde{\kappa} \sum_{s=1}^{T} \omega^s \beta^s \sum_{\tau=1}^{s} \hat{E}_t \hat{\pi}_{t+\tau}, \tag{26}$$

$$\tilde{b}_{t+1} = \frac{1}{\beta}\tilde{g}_t - \frac{\bar{\tau}^c}{\beta}(\hat{Y}_t - \tilde{g}_t) - \frac{1-\bar{g}}{\beta}\tilde{\tau}^c_t + \frac{1}{\beta}\tilde{b}_t + \bar{b}(\hat{i}_t - \frac{1}{\beta}\hat{\pi}_t)$$
$$- \frac{\bar{w}}{\beta}\left[\bar{\tau}^l \left((1+\eta+\frac{\sigma}{1-\bar{g}})\hat{Y}_t - \sigma\frac{\tilde{g}_t}{1-\bar{g}} + \frac{\tilde{\tau}^c_t}{1+\bar{\tau}^c} + \frac{\tilde{\tau}^l_t}{1-\bar{\tau}^l} - \xi_t\right) + \tilde{\tau}^l_t\right], \tag{27}$$

with coefficients defined in Appendix B.4.

Linearized monetary and fiscal policy equations are given by

$$\hat{i}_t = \phi_1 \hat{\pi}_t + \phi_2 \hat{Y}_t, \tag{28}$$

$$\tilde{g}_t = \tilde{DS}_t, \tag{29}$$

$$\tilde{\tau}^l_t = \tilde{DLT}_t + \gamma \tilde{b}_t, \tag{30}$$

$$\tilde{\tau}^c_t = \tilde{DCT}_t. \tag{31}$$

2.5 Expectations

There are two types of agents in the economy: forward-looking agents and backward-looking agents. Backward-looking agents consider the last observation of all variables, and consider this observation to be most informative about the current state of the economy, and its future evolution. They however do not expect the economy to stay in its current state forever, but instead expect mean-reversion to the target steady state in the future. In particular their expectations about output s periods from now is given by

$$E^b_t \hat{Y}_{t+s} = \rho^{s+1} \hat{Y}_{t-1} \tag{32}$$

Branch and McGough (2010) and Gasteiger (2014) and others refer to these expectations as adaptive expectations. Expectations about inflation, debt, the nominal interest rate, government spending, taxes and (in case of a positive inflation target) price dispersion are formed analogously. I assume that backward-looking agents always expect future realization of the preference shock to be zero.[1]

Forward-looking agents understand the mechanics of the economy. They also now what fraction of agents in the economy is backward-looking and what fraction is forward-looking. Moreover, they observe the expectations that backward-looking agents have formed in the current period, about the next T periods. They are however not rational enough to know exactly how backward-looking agents are forming their expectation. Therefore, forward-looking agents have no reason to believe that backward-looking agents will later revise currently formed expectations about a particular future period. Instead, forward-looking agents assume that backward-looking agents will stick with the expectations about future period that they have currently formed, and will only come up with new expectations when periods that currently still lie outside their planning horizon are concerned.[2] Mathematically, this implies $E_t^f[E_{t+k}^b Y_{t+s}] = E_t^b Y_{t+s}$, with $k < s \leq T$.

Moreover forward-looking agents are restricted in their ability to sophisticatedly think about the future, by their planning horizon. As in Lustenhouwer and Mavromatis (2017), I assume that forward-looking agents rationally use the model equations within their horizon to form model consistent expectations, but they are not able to form expectations for variables outside their horizon in a sophisticated manner.

Because of the above mentioned bounded rationality, forward-looking agents know the model equations and the structural form of the minimum state variable solution of the model, but their computed solution may not always be fully model consistent, as described below.

[1]This assumption is made because I want to highlight expectation driven liquidity traps that arise because backward-looking agents expect variables like output and inflation to remain low after a single, non persistent shock. I do not want to consider liquidity traps that arise because agents expect the shock itself to be persistent, even when it is not.

[2]In Section 3.4, robustness to the case of fully rational forward-looking agents is discussed.

Forward-looking agents start with forming expectations about the final period of their horizon. To do this, they take the model equations of period $t+T$. However, in the IS and Phillips curves of that period (Equations (25) and (26) forwarded T periods), finite sums with expectations about period $t+T+1$ up to period $t+T+T$ appear. That is, in the model equations they are considering, expectations of variables outside their planning horizon show up. Forward-looking agents therefore need to give these expectations a value, without being able to solve in a sophisticated manner what will happen in these periods (since they lie outside their planning horizon). Instead, they assume that in periods after their horizon, the model will have converged to a steady state, with all agents believing in steady state values for the future. With this assumption, they are able to solve for period $t+T$ variables in terms of the state variable b_{t+T}. They then move to the model equations of period $t+T-1$. Here they plug in the solution of period $t+T$ variables as expectations for forward-looking agents, and the current expectations about period $t+T$ of backward-looking agents as expectations for backward-looking agents. They then again assume steady state levels for expectations of variables outside their horizon. This allows them to solve for period $t+T-1$ variables in terms of state variable b_{t+T-1}. This process goes on until they have solved for all expectations of forward-looking agents within their horizon in terms of the observed state variable b_t. Expectations of variables for the periods within the horizon can then be obtained from these policy functions by plugging in the value of the current debt level.

3 Liquidity traps

In this section I show that in the above model with forward-looking and backward-looking agents liquidity traps can arise that are mainly driven by expectations rather than fundamentals. In order to highlight the role of expectations I initiate a liquidity trap by a single, non-persistent shock to the fundamentals of the economy that temporarily lowers output and inflation, in an economy with a relatively large fraction of backward-looking agents (75%). I compare this case of a liquidity trap driven by expectations of backward-looking agents, with the case of a liquidity trap driven by fundamentals, where the fundamental shock is persistent (auto-correlation coefficient of 0.85), and there are no backward-looking agents. The particular shock that I consider is a negative preference shock that decreases the rate at which households discount the future and creates a desire to save. Similar shocks are used to model a liquidity trap by e.g. Eggertsson (2011) and Mertens and Ravn (2014).[3]

Note that under fully rational expectations, a liquidity trap of multiple periods could arise in case of a persistent negative preference shock, but that it would at most last one period in the case of a single non-persistent shock. The intuition for an expectation driven liquidity trap to arise in the behavioral model, even after only a single non-persistent shock, is the following. In the behavioral model, a bad shocks can trigger pessimism in the economy, with backward-looking agents expecting low output and inflation for the future. This causes agents to reduce consumption and prices, so that the liquidity trap continues. The liquidity trap is then however purely driven by expectations, without any bad fundamentals.

Below, I illustrate how liquidity traps can arise (Section 3.2), and how the occurrence of expectation driven liquidity traps depends on the size of the shock and the fraction of backward-looking agents (Section 3.3). In addition, there is an important role for the planning horizon of agents. This will be the focus of Section 3.4. First, the parameterization is discussed in Section 3.1.

3.1 Parameterization

In the model, one period corresponds to one quarter. I set the discount factor to $\beta = 0.99$, the coefficient of relative risk aversion to $\sigma = 1$, the inverse of the Frisch elasticity of labor supply to $\eta = 2$, the elasticity of substitution to $\theta = 6$ and the Calvo parameter to $\omega = 0.75$. These values are relatively standard in the literature. Steady state fiscal

[3]Note that the particular form of the shock is not important for the main results of the paper. The only thing that matters for an expectation driven liquidity trap is that output and inflation are reduced for a single period, so that backward-looking agents adjust their expectations. The exact reason for output and inflation to have declined is of no consequence.

variables I choose more or less in line with US historical averages as follows: steady state government spending as a share of GDP is set at $\bar{g} = \bar{G}/\bar{Y} = 0.25$; the steady state labor and consumption tax rate are set to respectively $\bar{\tau}^l = 0.24$ and $\bar{\tau}^c = 0.08$, so that the steady state debt to GDP ratio becomes $\bar{b} = 1$. Monetary and fiscal policy variables are set to $\phi_1 = 1.5$ and $\phi_2 = 0.157$ (implying a response to output of around 0.6 when annual data are used) and $\gamma = 0.1$. I further set the mean reversion in the expectations of backward-looking agents to 0.85. With that calibration, backward-looking agents expect the deviation of variables to be halved in approximately 4 quarters. In Appendix D, I study robustness to the calibration of this parameter. As a benchmark, I fix agent's planning horizon at $T = 8$, but in most sections I present results for different planning horizons.

3.2 Illustration of expectation driven liquidity traps

Figure 1 plots, the simulated time series of output, inflation the nominal interest rate, taxes and debt and the preference shock. In the purple and dashed green cases there is a single, non-persistent negative preference shock in period 2 of -20%. In the dashed green case, all agents are forward-looking. Agents then know that there is no reason to adjust their inflation and output expectations considerably downward, because there is little inertia in the economy. This is because there is no auto-correlation in the preference shock and there are no backward-looking agents in the economy. In this case, the liquidity trap is immediately resolved in period 3, when the bad shock has passed.

The purple curves depict a liquidity trap driven by expectations, where 75% of agents in the economy are backward-looking. In the period after the negative preference shock, backward-looking agents adjust their inflation and output expectations downward, and expect the liquidity trap to continue. This causes backward-looking agents to lower consumption and prices. Forward-looking agents are aware of this, and rationally expect lower inflation as well, so that they also lower their prices somewhat compared to the case with no backward-looking agents. The lowering of prices of both backward- and forward-looking firms causes inflation to remain low in period 3. This causes the wave of pessimism to con-

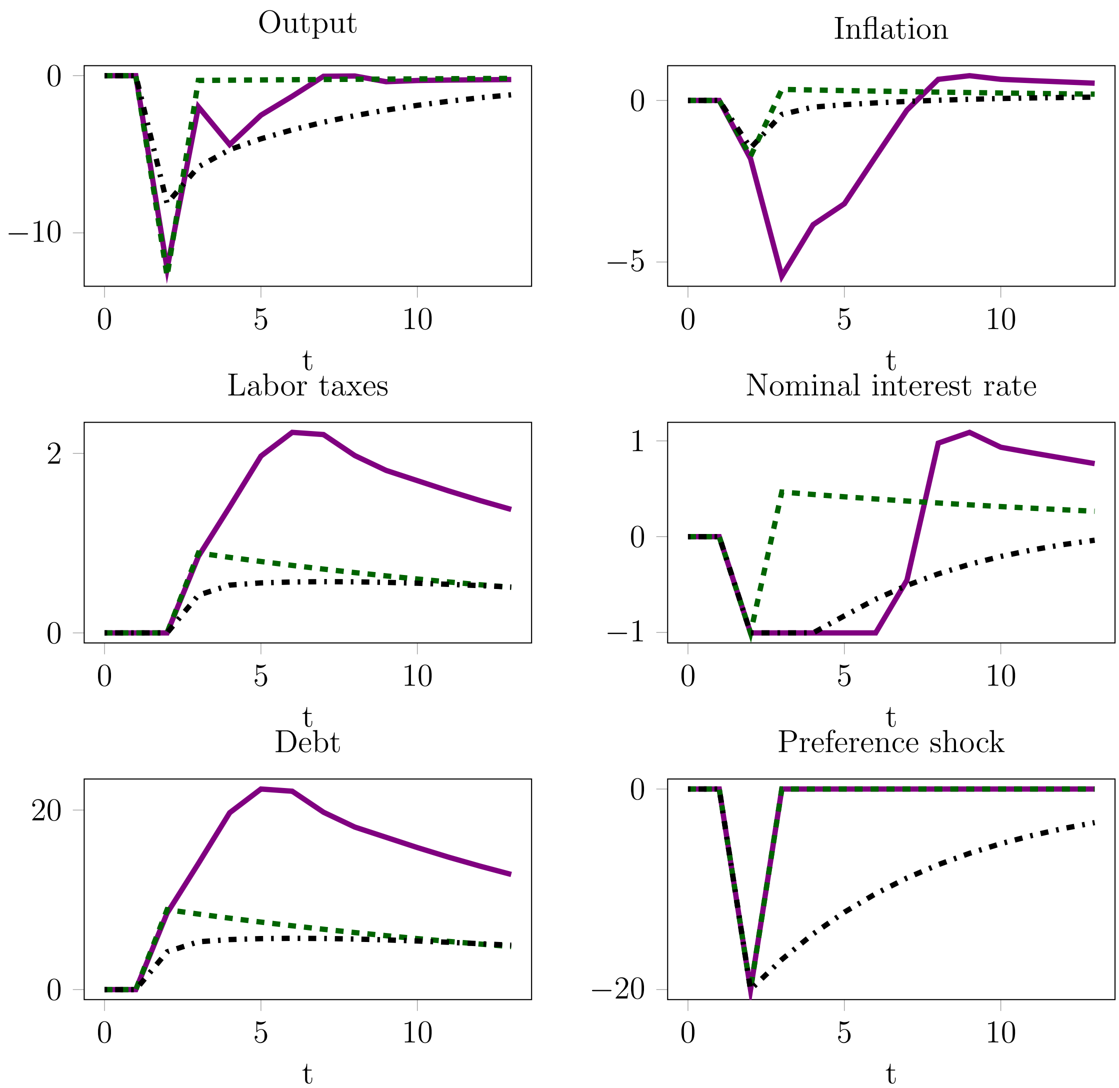


Figure 1: Liquidity traps for $T = 8$. The dashed green and solid purple curves depict the case of a single non-persistent shock with respectivley only forward-looking agents and 75% backward-looking agents (expectation driven liquidity trap). The dashed-dotted curve depicts the case of a liqudity trap driven by a persistent negative preference shock with only forward-looking agents.

tinue, and the expectation driven liquidity trap now lasts up to and including period 6 (a total of 5 quarters).

The black dashed-dotted curve depicts the case of a liquidity trap driven by fundamentals. Here all agents are forward-looking, but the negative preference shock is now persistent with auto-correlation coefficient 0.85. Because the fundamentals now remain low for a number of periods, agents in the economy choose relatively low consumption and prices for several periods. As a result, the liquidity trap now lasts up to and including period 5, even though there are now backward-looking agents in the economy.

3.3 Duration of liquidity trap

Next let us move to a more robust analysis of the model dynamics and the length of liquidity trap for different fractions of backward-looking agents and for different sizes of the fundamental shock. Panel (b) of Figure 2 displays the duration of the expectation driven liquidity trap in case of a planning horizon of 8. On the horizontal axis is the fraction of backward-looking agents and on the vertical axis is the size of the one-time negative preference shock (in absolute value). The figure shows the following. When the shock size is small, the zero lower bound does not become binding, and no liquidity trap arises. This is the lightest region and the bottom of the figure. When the shock is a bit larger but not too large, or when the fraction of backward-looking agents is small, the liquidity trap is immediately over after the fundamental shocks are over (duration of 1 period). This is the second lightest region in the bottom left of the figure. The dashed green case of Figure 1, where the fraction of backward-looking agents was 0, falls in that area. For larger fractions of backward-looking agents and/or larger shocks, the liquidity trap last longer and longer, as can be seen from the changing color shades.

Remember that the liquidity trap with duration 5 presented in purple in Figure 1 had a share of 0.75 backward looking agents and a shock size of 0.20%. In panel (b) of Figure 2 it can be seen that liquidity traps of longer duration arise when the negative preference shock is of larger magnitude, but especially if the fraction of backward-looking agents in the economy is made even higher.

3.4 Planning horizon

Now let us turn to the effect of the planning horizon of the agents on the liquidity traps. Figure 3 plots in purple the expectation driven liquidity of Figure 1, where the planning horizon equals 8 and the fraction of backward-looking agents is 75%. The dashed green curves in Figure 3 depict the case of a shorter horizon of $T = 4$, while the dashed-dotted black curves depict the case of the longer horizon of $T = 16$.

Comparing the output and inflation response to the initial fundamental shock in period 2, it can be seen that these responses are very similar for all three horizons. The differences in expectations of backward-looking agents in period 3 are therefore also not very large. Nonetheless, when the preference shock is over, the pessimistic expectations for $T = 8$ imply a prolonged expectation driven liquidity trap with slow convergence to the steady state, while similar expectations for $T = 4$ imply almost immediate convergence, and for $T = 16$ imply a rapid drop in output and inflation and a subsequent deflationary spiral. The reason for this is the effects that pessimistic expectations about the future have on agents' consumption, labor and pricing decisions. Short sighted agents only consider a small number of future periods when making decisions. For $T = 4$, backward-looking consumers expect increased real interest rates and lowered output for the next 4 periods, and reduce their consumption somewhat accordingly. However, they do not consider what might happen after these four periods when making their decisions. An agent with a planning horizon of $T = 16$ on the other hand, cares about considerably more future periods. When this agent expect real interest rates and output to be low also five periods from now and later, he will reduce his consumption more than an agent that looks only 4 periods into the future.[4]

[4]Note that there is also a role in this story for the coefficient of mean reversion in the expectations of backward-looking agents, d. In Appendix D it is shown that when this coefficient is reduced, liquidity traps last less long for a given shock size and fraction of backward-looking agents. It is furthermore shown that the differences between planning horizons are then reduced. The intuition for this is as follows. When backward-looking agents expect very fast mean reversion agents with longer horizons do not expect high

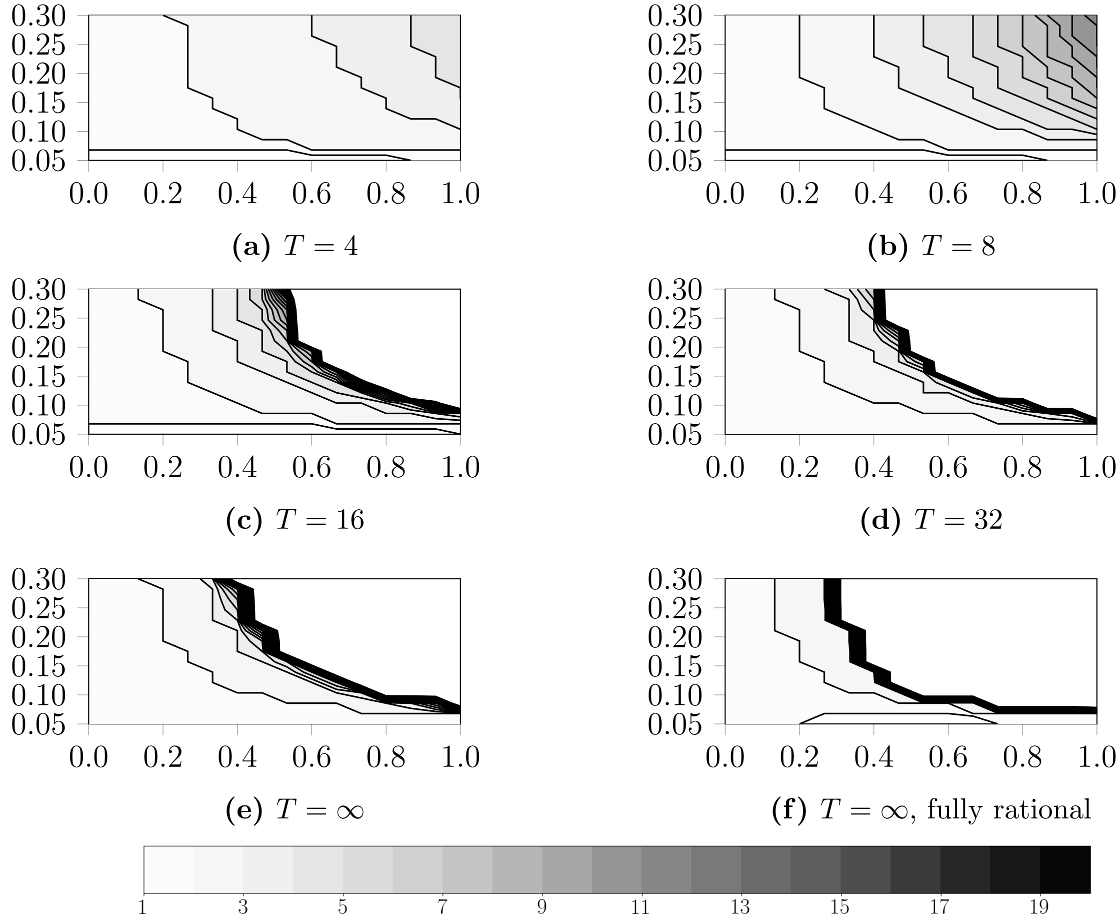


Figure 2: Length of liquidity trap for different fractions of backward-looking agents (x-axis) and different sizes of the (non-persistent) negative preference shock (y-axis). The different panels correspond to different planning horizons. Darker color shades indicate a longer duration of the liquidity trap. The fully white areas in the top right of the bottom 4 panels indicate liquidity traps of infinite length with ever decreasing inflation and output (deflationary spirals).

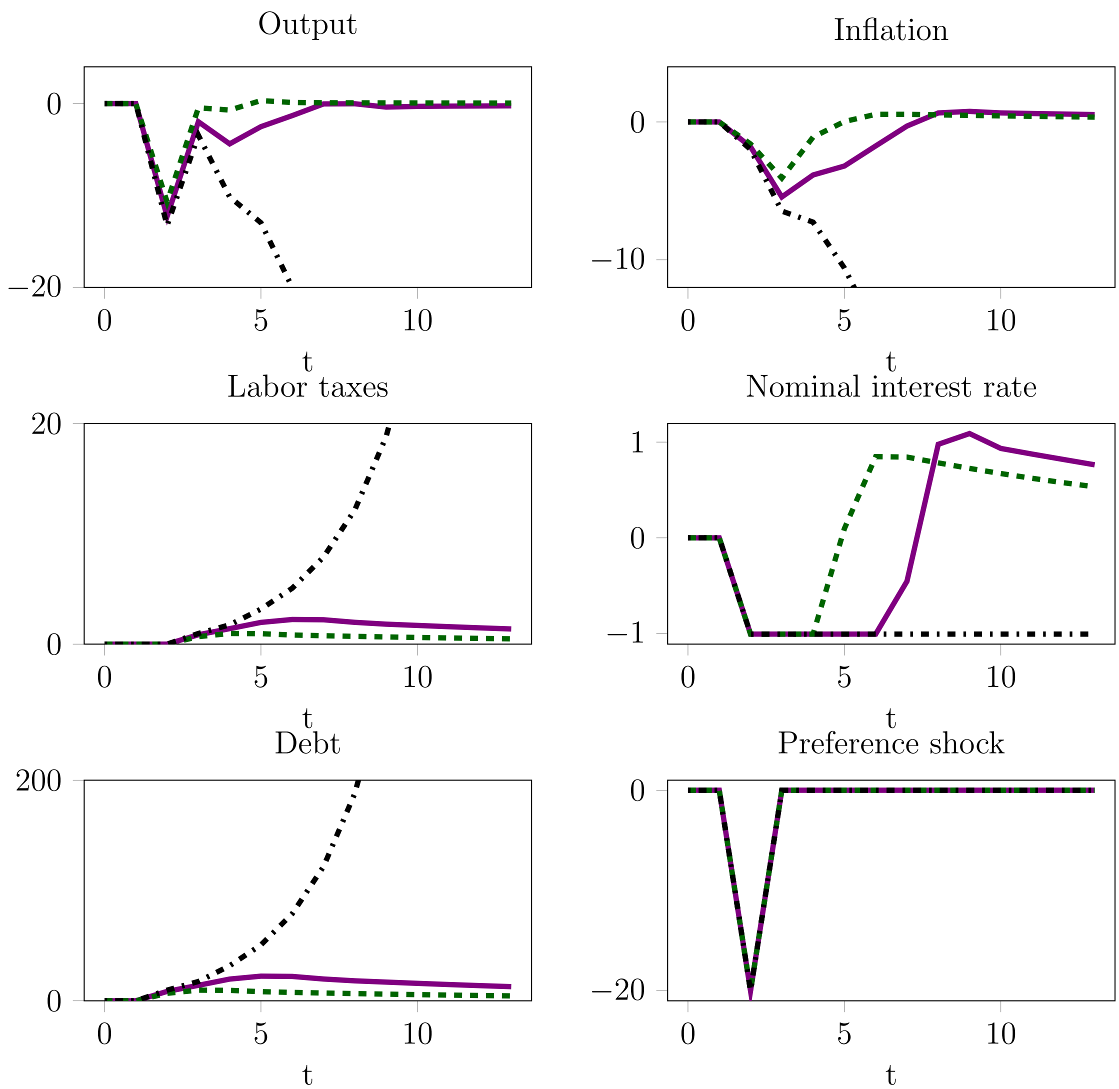


Figure 3: Expectation driven liquidity trap for $T = 4$ (dashed green), $T = 8$ (purple) and $T = 16$ (dashed-dotted black).

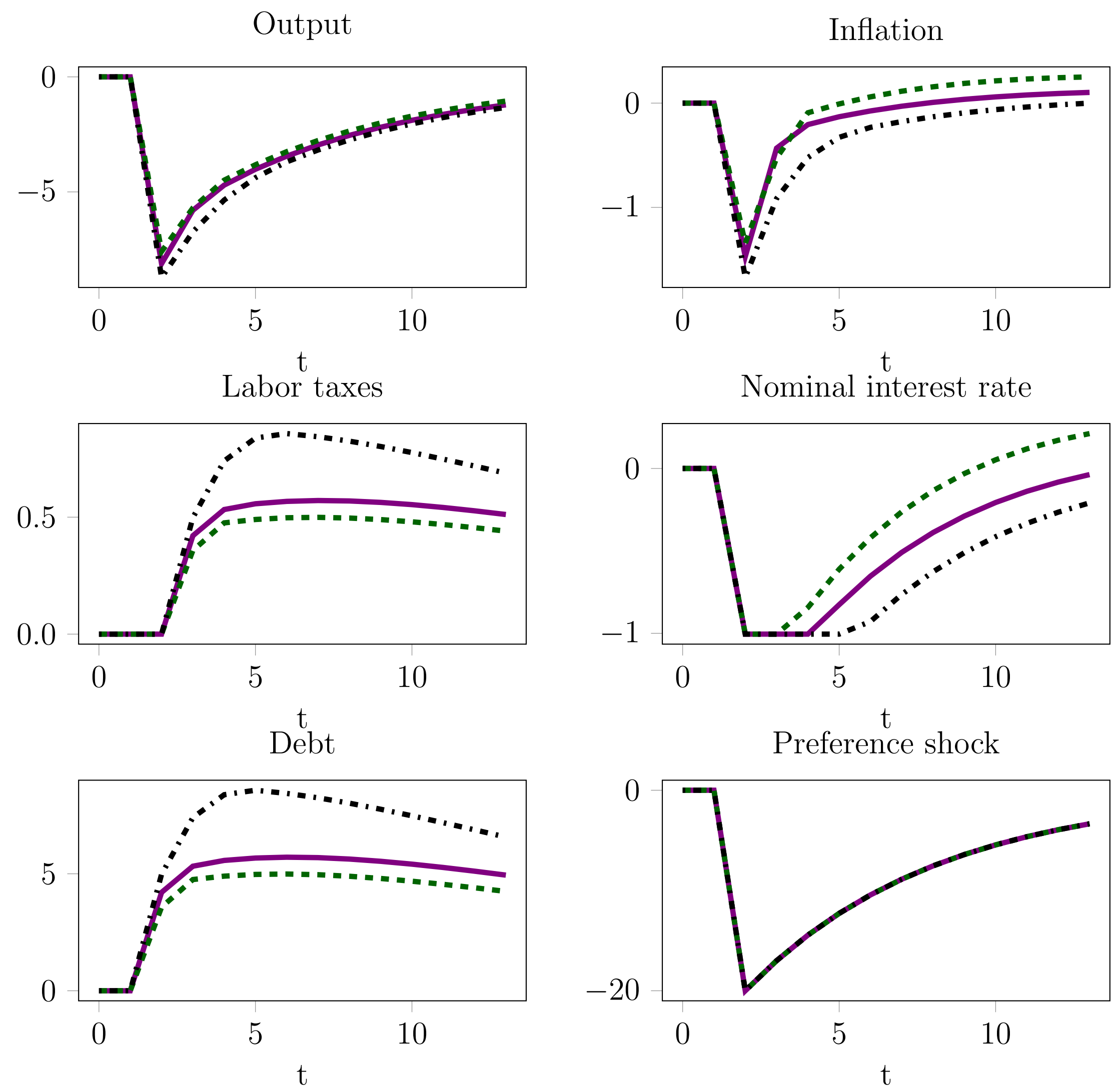


Figure 4: Fundamentals driven liquidity trap for $T = 4$ (dashed green), $T = 8$ (purple) and $T = 16$ (dashed-dotted black).

Figure 4 plots liquidity traps driven by fundamentals for different horizons. That is, all agents are forward-looking and the negative preference shock is persistent, as in the dashed-dotted black case of Figure 1. Again, purple corresponds to $T = 8$, dashed green to $T = 4$ and dashed-dotted black to $T = 16$. In the figure, it can be seen that the qualitative differences between the three curves are small. In all cases, output and inflation first fall and then slowly recover. Moreover, the length of the liquidity traps vary only a little (2-4 periods) for the different horizons, unlike in Figure 3. However, it remains the case that longer horizons lead to longer and deeper recessions and longer liquidity traps.

Now let us consider more generally what the change in planning horizon implies for different values of the shock size and different values of the fraction of backward-looking agents. Panels (a) of Figure 2 reproduces panel (b), but now with a planning horizon of $T = 4$ instead of $T = 8$. The liquidity trap now lasts at most 4 periods, and that only for a relatively high fraction of backward-looking agents. This reflects that a shorter horizon implies faster recovery and shorter liquidity traps for any given combination of the shock size and the fraction of backward-looking agents.

Panels (c) and (d) of Figure 2 plot the cases of respectively $T = 16$ and $T = 32$. Here it can be seen that as the fraction of backward-looking agents is increased, the liquidity traps last longer than in the case of $T = 8$. However for larger fractions of backward-looking agents and larger shock sizes, it is no longer the case that very long liquidity traps arise from which the economy eventually recovers. Instead, the economy falls in a deflationary spiral, as was illustrated by the green curve in Figure 3. In Figure 2, deflationary spirals with ever lasting liquidity traps are indicated by white areas. The intuition for such a deflationary spiral to arise is that backward-looking agents expect low inflation, high real interest rates and low output for most of the periods within their horizon, and hence reduce prices and consumption with considerable magnitude. When there are enough backward-looking agents in the economy, the resulting drop in inflation and output is enough to

real rates in the extra periods that they are considering and hence do not reduce consumption and prices more than short-sighted agents. It is further shown in Appendix D that when the coefficient of mean reversion in expectations is increased, liquidity traps last longer and deflationary spirals occur more often, also for shorter horizons.

make agents even more pessimistic in the next period, causing inflation and output to keep falling further and further.

Panel (e) of Figure 2 plots the case of an infinite planning horizon. The results are very similar to those in panel (d), but also to those in panel (c). Deflationary spirals occur somewhat more, but not drastically so. This is because backward-looking agents expect the economy to have more or less returned to steady state after 16 periods, so that backward-looking agents with a planning horizon longer than 16 periods do not base their consumption and pricing decisions on a longer sequence of low inflation and high real interest rates than agents with a planning horizon of 16 periods.

Note that in panel (e) the assumption is maintained that forward-looking agents do not anticipate revisions in expectations of backward-looking agents. In panel (f) I relax this assumption as a robustness check, and allow the forward-looking agents to become fully rational. Panel (e) and (f) look qualitatively very similar with short liquidity traps for small fractions of backward-looking agents and small shock-sizes and deflationary spirals in case of larger fractions of backward-looking agents with a larger shock size. It can therefore be concluded that the above mentioned assumption is not very impotent for the qualitative dynamics that the model displays, but only slightly alters dynamics quantitatively. The model equations used to create the graphs in panel (e) and (f) of Figure 2 are derived in Appendix C.

4 Fiscal stimulus

Now lets consider whether fiscal stimulus in the form of a temporary increase in government spending or cut in labor or consumption taxes can mitigate an expectation driven liquidity trap. In particular, assume that the government implements a stimulus package in period 3 (the period after the start of the liquidity trap), and that the the stimulus package is persistent, with auto-correlation coefficient 0.7.[5]

[5] I find similar results if the stimulus is not persistent, or has a different auto-correlation coefficient. However, the lower the persistence in the stimulus package, the larger the initial stimulus needed to realize a required effect, which may lead to unreasonably large changes in fiscal variables.

Moreover I first assume in Section 4.1 that the size of the initial spending increase is half the size of the initial negative preference shock. In Sections 4.2 and 4.3, I investigate what size of the stimulus package would be needed in order to prevent a deflationary spiral for respectively the benchmark calibration and the case of a positive inflation target. The sizes of the labor tax and consumption tax cuts will always be scaled by respectively $\frac{1}{\bar{w}}$ and $\frac{1}{1-\bar{g}}$, so that all stimulus measures have the same direct impact on the government's budget deficit, and hence are comparable.

4.1 Spending increases and tax cuts

The solid purple curves in Figures 5 and 6 again reproduce the expectation and fundamentals driven liquidity traps of Figures 1. The other graphs show the time series in case of a fiscal stimulus package starting from period 3. In particular, dashed green corresponds to a spending increase, dashed-dotted black corresponds to a labor tax cut, and dotted blue depicts the case of a cut in consumption taxes.[6]

First focusing on the dashed green cases, the following can be observed. When government spending is increased in period 3, both output and inflation are increased considerably. Moreover, because forward-looking agents realize that the persistent spending increase will keep output and inflation high, they raise their output and inflation expectations, and increase consumption and prices. In Figure 6 this leads to an immediate end to the liquidity trap. In Figure 5 there are not enough forward-looking agents to immediately end the liquidity trap in period 3. However, in period 4 backward-looking agents also raise their expectations because they observed higher output and inflation in period 3. Therefore I find that also in case of an expectation driven liquidity trap, spending increases can be highly effective in ending a liquidity trap.

Next, consider the dashed-dotted black case of cutting labor taxes. As can be seen in Figure 5 and 6 this measure raises output somewhat. However cutting labor taxes is deflationary both in the liquidity trap driven by fundamentals an ind the liquidity trap

[6]I have assumed that the implementation of the stimulus package is announced and anticipated in period 2. Assuming unanticipated fiscal stimulus in period 3 results in very similar graphs.

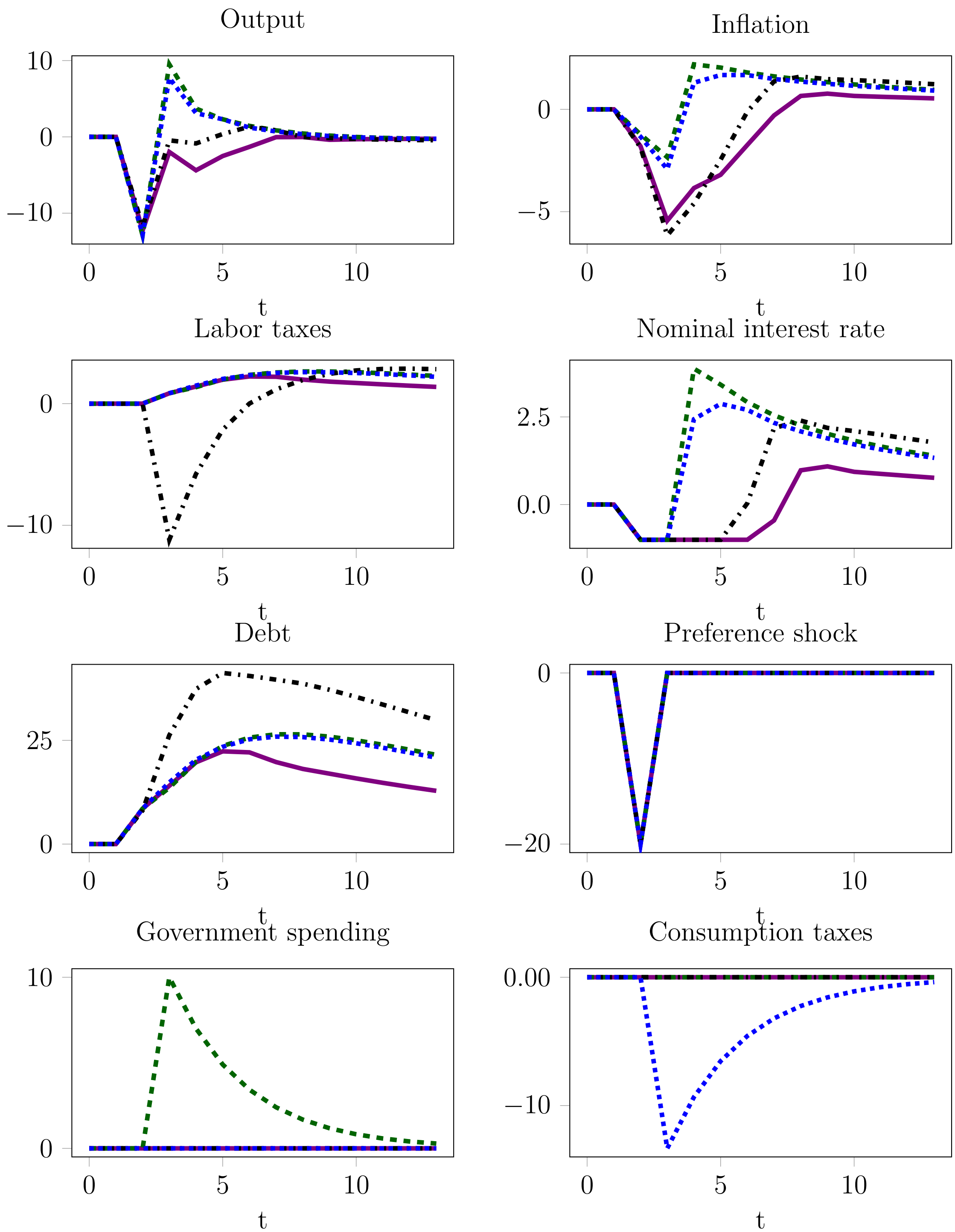


Figure 5: Expectation driven liquidity trap for $T = 8$. The solid purple curves depict the case of no fiscal stimulus, while dashed green corresponds to an increase in government spending, dashed dotted black to a cut in labor taxes and dotted blue to a cut in consumption taxes.

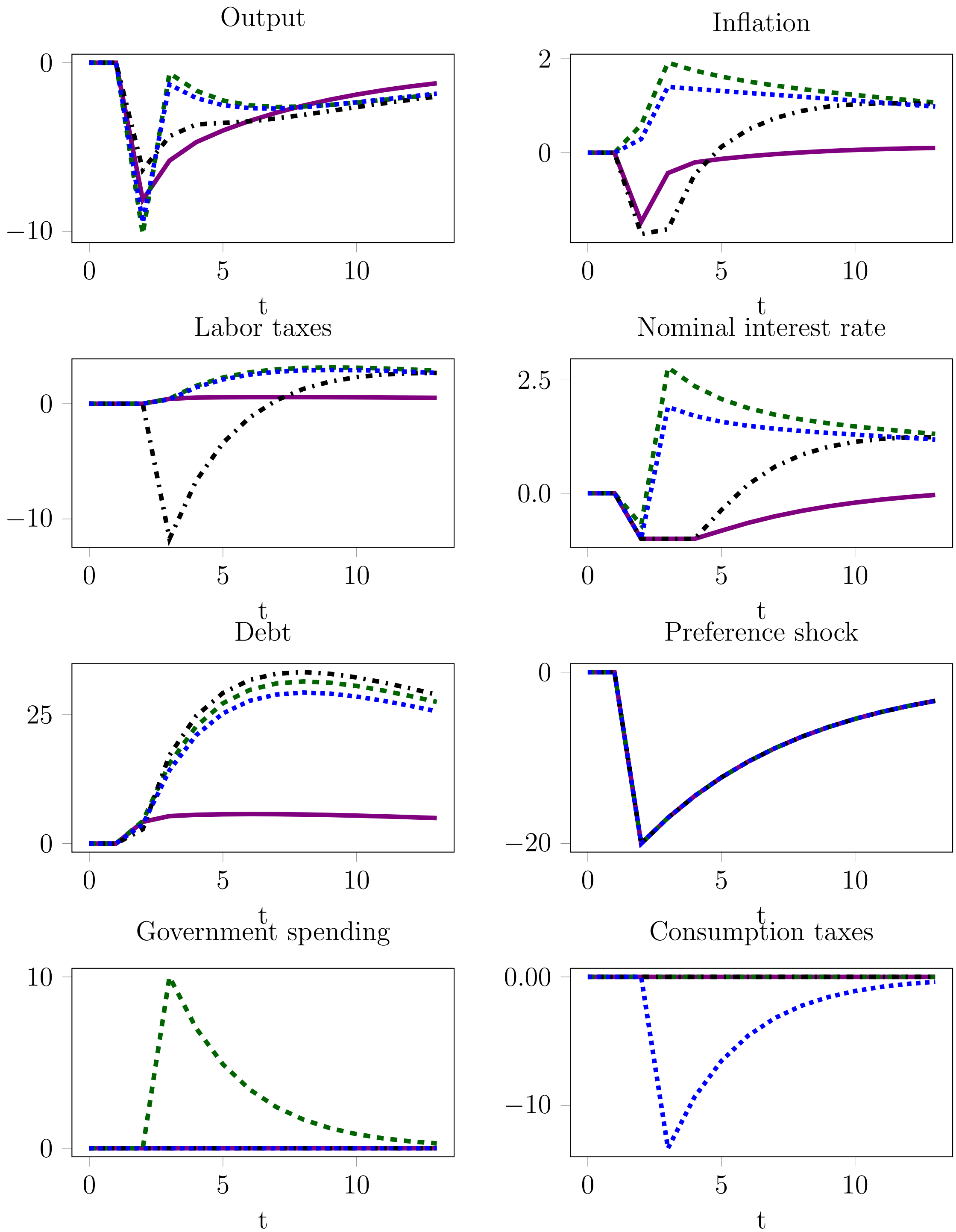


Figure 6: Fundamentals driven liquidity trap for $T = 8$. The solid purple curves depict the case of no fiscal stimulus, while dashed green corresponds to an increase in government spending, dashed dotted black to a cut in labor taxes and dotted blue to a cut in consumption taxes.

driven by expectations. The zero lower bound now remains binding and the increase in output is limited by an increase in the real interest rate. All in this stimulus package is only able to reduce the length of the binding zero lower bound by one period in case of the expectation driven liquidity trap and not at all in the liquidity trap driven by fundamentals.

Finally, lets turn to the case of cutting consumption taxes depicted in dotted blue. Unlike cutting labor taxes, this measure leads to inflationary pressures. This first of all directly mitigates the zero lower bound problem, and secondly implies a lower real interest rate, and a further increase in consumption and output. All in all, output and inflation rise somewhat less than under spending increases, but the consumption tax cuts are as effective in ending both the expectation driven and the fundamentals driven liquidity trap.

The result that a spending increase or a consumption tax cut can quickly end a liquidity trap, while a labor tax cut only slightly reduces its length is robust to the fraction of backward-looking agents and the shock size. This can be seen in panel (b) of Figures 7, 8 and 9 that reproduce Figure 2 for the cases of respectively spending increases, labor tax cuts, and consumption tax cuts.

Moreover, the same general result appears for different planning horizons. It can be seen in panel (a) of Figures 7, 8 and 9 that the liquidity trap is resolved more quickly under spending based stimulus and consumption tax cuts than under labor taxes cuts, also when the horizon is short. Comparing panels (d) and (e) of Figures 7, 8 and 9 with those of Figures 2, it can be seen that for longer horizons spending increases and consumption tax cuts shorten liquidity traps and reduce the risks of deflationary spirals, while labor tax cuts do not lead to visible improvements.

4.2 Size of stimulus package

In section 4.1, the size of the spending stimulus was equal to half the size of the negative preference shock. This is arguably somewhat ad hoc. Moreover, for both spending and tax based stimulus deflationary spirals still occurred for longer horizons when the shock size and the fraction of backward-looking agents are large. Table 1 presents the size of the

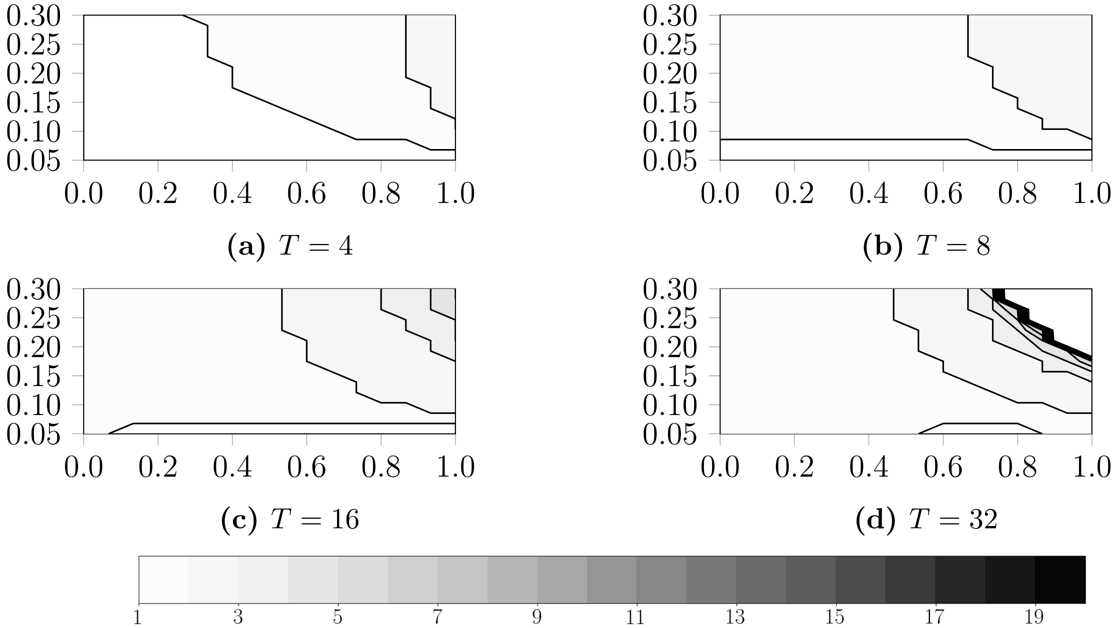


Figure 7: Length of liquidity trap in case of persistent **spending stimulus** for different fractions of backward-looking agents (x-axis), different sizes of the (non-persistent) negative preference shock (y-axis) and different horizons (the four panels).

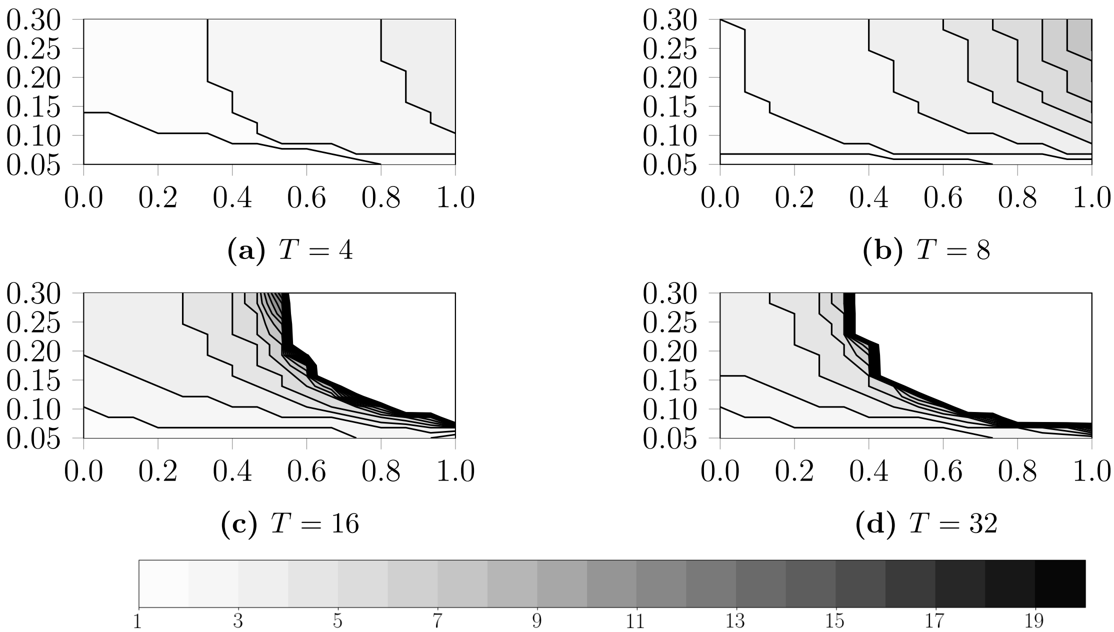


Figure 8: Length of liquidity trap in case of persistent **labor tax cuts** for different fractions of backward-looking agents (x-axis), different sizes of the (non-persistent) negative preference shock (y-axis) and different horizons (the four panels).

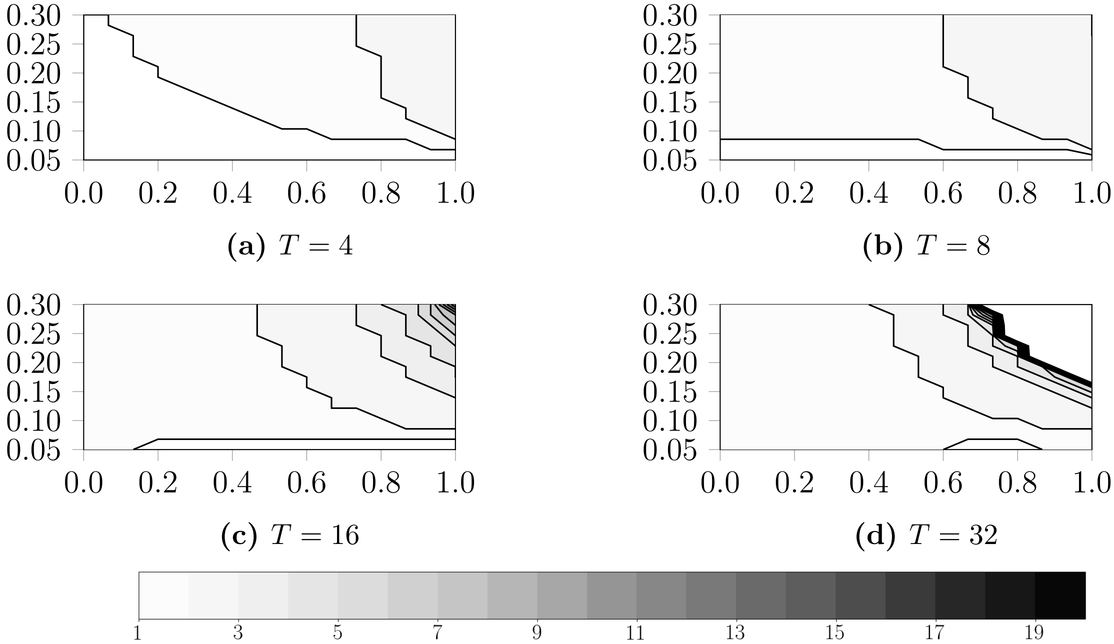


Figure 9: Length of liquidity trap in case of persistent **consumption tax cuts** for different fractions of backward-looking agents (x-axis), different sizes of the (non-persistent) negative preference shock (y-axis) and different horizons (the four panels).

initial stimulus that is required to prevent a deflationary spiral for different shock sizes and different fractions of backward-looking agents, in case of a planning horizon of $T = 16$.[7] The table only presents the cases of a spending increase and of a consumption tax cut, because I find that a cut in labor taxes can never prevent a deflationary spiral, no matter how large the cut.

It can be seen in panel a of Table 1 that for a shock size of 0.05 no fiscal stimulus is required to prevent a deflationary spiral and for a shock size of 0.1, only for large fractions of backward-looking agents. This is in line with panel (c) of Figure 2 where no deflationary spirals occur in that area. As the shock size and/or the fraction of backward-looking agents is increased in Table 1, larger spending increases are needed to prevent a deflationary spiral. For very large shocks and large fractions of backward-looking agents the required

[7] As was found in the previous section, increasing the horizon above 16 (to 32 or even to infinity) does not drastically increase the occurrence of deflationary spirals. Therefore the required sizes of a stimulus package for longer horizons is somewhat higher, but generally similar to the numbers presented in Table 1.

Panel a: Increase in $\tilde{g}_t$ (government spending)

shock size \ frac BL	0.5	0.6	0.7	0.8	0.9	1
0.3	0	4	7	10	12	13
0.25	0	2	5	7	9	10
0.2	0	0	3	5	6	7
0.15	0	0	0	2	3	4
0.1	0	0	0	0	0	1
0.05	0	0	0	0	0	0

Panel b: Cut in $\tilde{\tau}_t^c(1-\bar{g})$ (consumption taxes)

shock size \ frac BL	0.5	0.6	0.7	0.8	0.9	1
0.3	0	4	8	11	14	15
0.25	0	2	6	8	10	12
0.2	0	0	3	5	7	8
0.15	0	0	0	2	3	4
0.1	0	0	0	0	0	1
0.05	0	0	0	0	0	0

Table 1: Required magnitude of fiscal stimulus to prevent deflationary spiral for different shock sizes and fractions of backward-looking agents when agents have a planning horizon of $T = 16$.

size exceeds the size that was assumed in Figure 7, which explains why deflationary spirals still occurred in panel (c) of that figure. This means however, that with slightly larger spending increases deflationary spirals could have been prevented all together in panel (c) of Figure 7.

Turning to panel *b* of Table 1 it can be seen that consumption taxes can also prevent deflationary spirals and that their required magnitudes (after re-scaling with steady the steady state consumption to output ratio, $\frac{\bar{C}}{\bar{Y}} = 1 - \bar{g}$, to make their direct impact on the governments budget deficit equal to that of a spending increase) are slightly larger than the required government spending increases. Note however that given the relatively low calibration of steady state consumption taxes, the cuts required to prevent deflationary spirals for large shocks and a large fraction of backward-looking agents may be unrealistically high and require consumption taxes to become negative. In this case a combination of spending increases and consumption tax cuts may be a more realistic, better balanced way to proceed. Moreover, as shown in the next section, the required size of a stimulus package can be considerably decreased in case of a positive inflation target.

Panel a: Increase in $\tilde{g}_t$ (government spending)

shock size \ frac BL	0.5	0.6	0.7	0.8	0.9	1
0.3	0	0	3	6	7	9
0.25	0	0	1	3	5	6
0.2	0	0	0	1	2	3
0.15	0	0	0	0	0	0
0.1	0	0	0	0	0	0
0.05	0	0	0	0	0	0

Panel b: Cut in $\tilde{\tau}_t^c(1-\bar{g})$ (consumption taxes)

shock size \ frac BL	0.5	0.6	0.7	0.8	0.9	1
0.3	0	0	3	6	9	10
0.25	0	0	1	3	5	7
0.2	0	0	0	1	2	3
0.15	0	0	0	0	0	0
0.1	0	0	0	0	0	0
0.05	0	0	0	0	0	0

Table 2: Required magnitude of fiscal stimulus to prevent deflationary spiral for different shock sizes and fractions of backward-looking agents when agents have a planning horizon of $T = 16$ and the central bank targets inflation of annualized 2%.

4.3 Fiscal stimulus under positive inflation target

So far I have assumed that the central bank has an inflation target of zero. It turns out that in my model a higher inflation target decrease the occurrence, severity and duration of liquidity trap for a given shock size. This is intuitive, as a positive inflation target implies a higher steady state nominal interest rate, so that there is more room to decrease interest rates until the zero lower bound is hit. Therefore, a liquidity trap of given severity only arises with larger shocks when the inflation target is set higher.

This also implies that for a given shock size and fraction of backward-looking agents a smaller fiscal stimulus package is required to reduce a liquidity trap to a given duration, or to prevent a deflationary spiral. This is illustrated in Table 2 that reproduces Table 1 for the case of an annualized inflation target of 2%. It can be seen in Table 2 that for smaller shocks and/or smaller fractions of backward-looking agents deflationary spirals do not arise at all anymore, and no fiscal intervention is needed (as indicated by 0's). Moreover, for larger shock sizes and large fractions of backward-looking agents the required size of the stimulus package is considerably reduced compared to Table 1 where the inflation target was zero. This holds for both spending increases and labor tax cuts. As before, labor tax cuts are not effective in preventing liquidity traps, and this case is therefore not shown in Table 2.

5 Conclusion

I present a New Keynesian model with two forms of bounded rationality. First of all all agents in the economy have a finite planning horizon and are not able to base their consumption and pricing decisions upon considerations and expectations about the infinite future. Secondly, while one fraction of agents is forward-looking and uses the model equations to form expectations, another fraction of agents forms expectations in a backward-looking manner, based on the most recently observed state of the economy. They expect a similar economic situation to continue in the short run, but expect mean reversion to the target steady state in the medium to long run.

The presence of backward-looking agents in the economy can result in a liquidity trap of multiple periods, driven by expectations, after a single negative shock to the economy. The duration of such an liquidity trap crucially depends on the fraction of backward-looking agents in the economy, the size of the shock that triggered the liquidity trap, and agents' planning horizons. When these quantities are low, the liquidity trap lasts at most one or two periods. Expectation driven liquidity traps of longer duration can arise if the planing horizon is still relatively short, but the fraction of backward-looking agents becomes larger. When both the planning horizon and the fraction of backward-looking agents are large, it can occur that the economy never recovers from the liquidity trap, but instead falls in a deflationary spiral.

I show that fiscal stimulus in the form of a spending increase or a cut in consumption taxes can be very effective in reducing the length of the liquidity trap. Moreover, when the stimulus is of the appropriate size, deflationary spirals can always be prevented. Labor tax cuts on the other hand, are not very effective in reducing the length of the liquidity traps, and are not able to prevent deflationary spirals, independent of the size of the tax cut. The intuition for this is that, as in a standard liquidity trap driven by fundamentals, spending increases and consumption tax cuts are inflationary in my expectation driven liquidity traps, while labor tax cuts are deflationary. This result is in contrast with the findings of Mertens and Ravn (2014) who find that in a liquidity trap driven by a sunspot shock spending increases are deflationary while labor tax cuts are inflationary.

Finally, I find that a higher inflation target reduces the severity and duration of liquidity traps. Therefore, smaller fiscal stimulus packages are needed to mitigate liquidity traps and prevent deflationary spiral when the monetary authority targets higher inflation.

References

Assenza, T., P. Heemeijer, C. Hommes, and D. Massaro (2014). Managing self-organization of expectations through monetary policy: a macro experiment. Technical report, CeNDEF Working Paper, University of Amsterdam.

Benhabib, J., G. W. Evans, and S. Honkapohja (2014). Liquidity traps and expectation dynamics: Fiscal stimulus or fiscal austerity? *Journal of Economic Dynamics and Control 45*, 220–238.

Branch, W., G. W. Evans, and B. McGough (2010). Finite horizon learning.

Branch, W. A. (2004). The theory of rationally heterogeneous expectations: Evidence from survey data on inflation expectations. *The Economic Journal 114*(497), 592–621.

Branch, W. A. (2007). Sticky information and model uncertainty in survey data on inflation expectations. *Journal of Economic Dynamics and Control 31*(1), 245–276.

Branch, W. A. and B. McGough (2009). A new keynesian model with heterogeneous expectations. *Journal of Economic Dynamics and Control 33*(5), 1036–1051.

Branch, W. A. and B. McGough (2010). Dynamic predictor selection in a new keynesian model with heterogeneous expectations. *Journal of Economic Dynamics and Control 34*(8), 1492–1508.

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of monetary Economics 12*(3), 383–398.

Christiano, L., M. Eichenbaum, and S. Rebelo (2009). When is the government spending multiplier large? Technical report, National Bureau of Economic Research.

Coenen, G., C. J. Erceg, C. Freedman, D. Furceri, M. Kumhof, R. Lalonde, D. Laxton, J. Lindé, A. Mourougane, D. Muir, et al. (2012). Effects of fiscal stimulus in structural models. *American Economic Journal: Macroeconomics 4*(1), 22–68.

Correia, I., E. Farhi, J. P. Nicolini, and P. Teles (2013). Unconventional fiscal policy at the zero bound. *American Economic Review 103*(4), 1172–1211.

Deák, S., P. Levine, J. Pearlman, and B. Yang (2017). Internal rationality, learning and imperfect information.

Eggertsson, G. B. (2011). What fiscal policy is effective at zero interest rates? In *NBER Macroeconomics Annual 2010, Volume 25*, pp. 59–112. University of Chicago Press.

Elton, B., G. Di Bartolomeo, and D. P. Marco (2017). Bounded-rationality and heterogeneous agents: Long or short forecasters? Technical report, Department of Communication, University of Teramo.

Erceg, C. and J. Lindé (2014). Is there a fiscal free lunch in a liquidity trap? *Journal of the European Economic Association 12*(1), 73–107.

Evans, G. W., E. Guse, and S. Honkapohja (2008). Liquidity traps, learning and stagnation. *European Economic Review 52*(8), 1438–1463.

Evans, G. W. and S. Honkapohja (2009). Expectations, deflation traps and macroeconomic policy.

Gasteiger, E. (2014). Heterogeneous expectations, optimal monetary policy, and the merit of policy inertia. *Journal of Money, Credit and Banking 46*(7), 1535–1554.

Gasteiger, E. (2017). Optimal constrained interest-rate rules under heterogeneous expectations. Technical report, mimeo.

Hommes, C., D. Massaro, and I. Salle (2015). Monetary and fiscal policy design at the zero lower bound–evidence from the lab.

Lustenhouwer, J. and K. Mavromatis (2017). Fiscal consolidations and finite planning horizons. Technical report, Bamberg University, Bamberg Economic Research Group.

Massaro, D. (2013). Heterogeneous expectations in monetary dsge models. *Journal of Economic Dynamics and Control 37*(3), 680–692.

Mertens, K. R. and M. O. Ravn (2014). Fiscal policy in an expectations-driven liquidity trap. *Review of Economic Studies 81*(4), 1637–1667.

Pfajfar, D. and B. Zakelj (2011). Inflation expectations and monetary policy design: Evidence from the laboratory. Technical report, CentER Discussion Paper Series.

Woodford, M. (2011). Simple analytics of the government expenditure multiplier. *American Economic Journal: Macroeconomics 3*(1), 1–35.

Woodford, M. (2018). Monetary Policy Analysis When Planning Horizons Are Finite. In *NBER Macroeconomics Annual 2018, volume 33*, NBER Chapters. National Bureau of Economic Research, Inc.

A Steady state

In this section the steady state of the non-linear model is derived, where the preference shock is assumed to be constant at $\xi = 1$.

From the consumer Euler equation it follows that in this steady state we must have

$$\frac{1+\bar{i}}{\bar{\Pi}} = \frac{1}{\beta} \tag{33}$$

Furthermore, from (64) it follows that

$$\bar{H} = \bar{s}\bar{Y} \tag{34}$$

Next, we can solve the steady state aggregate resource constraint, (20), for consumption, and write

$$\bar{C} = \bar{Y}(1-\bar{g}) \tag{35}$$

Plugging in these steady state labor and consumption levels in the steady state version of the optimal labor/consumption trade off gives

$$\bar{mc} = \bar{w} = \frac{\bar{s}^{\eta}\bar{Y}^{\eta+\sigma}(1-\bar{g})^{\sigma}(1+\bar{\tau}^{c})}{1-\bar{\tau}^{l}} \tag{36}$$

So that steady state output can be written as

$$\bar{Y} = \left(\frac{\bar{mc}(1-\bar{\tau}^{l})}{\bar{s}^{\eta}(1-\bar{g})^{\sigma}(1+\bar{\tau}^{c})}\right)^{\frac{1}{\eta+\sigma}} \tag{37}$$

For the relative optimal price, we write (17) as

$$\bar{d} = \left(\frac{1-\omega\Pi^{\theta-1}}{1-\omega}\right)^{\frac{1}{1-\theta}} \tag{38}$$

For price dispersion, we then write

$$\bar{s} = \frac{(1-\omega)}{1-\omega\bar{\Pi}^{\theta}}\bar{d}^{-\theta} = \frac{(1-\omega)}{1-\omega\bar{\Pi}^{\theta}}\left(\frac{1-\omega\Pi^{\theta-1}}{1-\omega}\right)^{\frac{\theta}{\theta-1}} \tag{39}$$

Evaluating (52) at the steady state gives

$$\bar{mc} = \bar{d}\frac{\theta-1}{\theta}\frac{\sum_{s=0}^{T}\omega^s\beta^s\bar{\Pi}^{s(\theta-1)}}{\sum_{s=0}^{T}\omega^s\beta^s\bar{\Pi}^{s(\theta)}} = \left(\frac{1-\omega\Pi^{\theta-1}}{1-\omega}\right)^{\frac{1}{1-\theta}}\frac{\theta-1}{\theta}\frac{(1-\omega\beta\Pi^{\theta})(1-(\omega\beta\Pi^{\theta-1})^T)}{(1-(\omega\beta\Pi^{\theta})^T)(1-\omega\beta\Pi^{\theta-1})} \tag{40}$$

Firm profits we can write as

$$\bar{\Xi} = (1-\bar{w}\bar{s})\bar{Y} \tag{41}$$

Then we turn to the government budget constraint. In steady state (19) reduces to

$$\frac{\beta\bar{b}}{\bar{\Pi}} = (1+\bar{\tau}^c)\bar{g} - \bar{\tau}^l\bar{w}\bar{s} - \bar{\tau}^c + \frac{\bar{b}}{\bar{\Pi}}, \tag{42}$$

which gives

$$\bar{b} = \bar{\Pi}\frac{(\bar{\tau}^l\bar{w}\bar{s} + \bar{\tau}^c - (1+\bar{\tau}^c)\bar{g})}{1-\beta}, \tag{43}$$

Steady state government spending and taxes must be equal to their steady state discretionary parts

$$\bar{DS} = \bar{g}, \bar{DLT} = \bar{\tau}^l, \bar{DCT} = \bar{\tau}^c.$$

Finally we, assume that households value real bond holdings relative to consumption such that, in steady state they make optimal decisions. It then follows from (9) and (43) that

$$\Lambda = \frac{1}{\bar{\Pi}}\left(\frac{\bar{b}}{1-\bar{g}}\right)^{\sigma} = \bar{\Pi}^{\sigma-1}\left(\frac{(\bar{\tau}^l\bar{w}\bar{s} + \bar{\tau}^c - (1+\bar{\tau}^c)\bar{g})}{(1-\bar{g})(1-\beta)}\right)^{\sigma}. \tag{44}$$

B Log-linearized model

In this Section, I log-linearize the model equations around the steady state.

B.1 Households

The log linearized optimality conditions of the households (including budget constraints) are given by

$$\hat{C}^i_\tau = \hat{C}^i_{\tau+1} - \frac{1}{\sigma}(i_\tau - \hat{\pi}_{\tau+1} + \xi_{\tau+1} - \xi_\tau - \frac{\tilde{\tau}^c_{\tau+1} - \tilde{\tau}^c_\tau}{1+\bar{\tau}^c}), \qquad \tau = t, t+1, ...t+T-1 \tag{45}$$

$$\tilde{b}^i_{t+T+1} = \bar{b}\hat{C}^i_{t+T} + \frac{\bar{b}}{\sigma}\frac{\tilde{\tau}^c_{t+T}}{1+\bar{\tau}^c} + \frac{\bar{b}}{\sigma}E^i_t i_{t+T} + \frac{\bar{b}}{\sigma}(\xi_{t+T+1} - \xi_{t+T}), \tag{46}$$

$$\eta\hat{H}^i_\tau = -\sigma\hat{C}^i_\tau - \frac{\tilde{\tau}^c_\tau}{1+\bar{\tau}^c} - \frac{\tilde{\tau}^l_\tau}{1-\bar{\tau}^l} + \hat{w}_\tau + \xi_\tau, \qquad \tau = t, t+1, ...t+T \tag{47}$$

$$\begin{aligned}\tilde{b}^i_{\tau+1} =& \frac{\bar{w}\bar{s}\bar{\Pi}}{\beta}((1-\bar{\tau}^l)(E^i_t\hat{w}_\tau + \hat{H}^i_\tau) - E^i_t\tilde{\tau}^l_\tau) + \frac{1}{\beta}\tilde{b}^i_\tau + \bar{b}(\hat{i}_\tau - \frac{1}{\beta}E^i_t\hat{\pi}_\tau) + \frac{\bar{\Xi}\bar{\Pi}}{\bar{Y}\beta}E^i_t\hat{\Xi}_\tau \\ &- \frac{(1-\bar{g})\bar{\Pi}}{\beta}\left((1+\bar{\tau}^c)\hat{C}^i_\tau + \tilde{\tau}^c_\tau\right), \qquad \tau = t, t+1, ...t+T\end{aligned} \tag{48}$$

where it is used that $\bar{H} = \bar{s}\bar{Y}$ and $\frac{\bar{C}}{\bar{Y}} = 1 - \bar{g}$

Iterating the budget constraint T periods, and using the first order conditions of the household, the following equation can be derived, that describes a households optimal consumption decision in period t.

$$
\begin{aligned}
&\left(\beta^{T+1}\bar{b}+\left(\frac{\sigma}{\eta}\bar{w}\bar{s}(1-\bar{\tau}^{l})+(1+\bar{\tau}^{c})(1-\bar{g})\right)\bar{\Pi}\frac{1-\beta^{T+1}}{1-\beta}\right)\hat{C}_{t}^{i}=\\
&\tilde{b}_{t}^{i}+\bar{w}\bar{s}\bar{\Pi}(1-\bar{\tau}^{l})\sum_{s=0}^{T}\beta^{s}\left((1+\frac{1}{\eta})(E_{t}^{i}\hat{w}_{t+s}-\frac{E_{t}^{i}\tilde{\tau}_{t+s}^{l}}{1-\bar{\tau}^{l}})+\frac{1}{\eta}(E_{t}^{i}\xi_{t+s}-\frac{E_{t}^{i}\tilde{\tau}_{t+s}^{c}}{1+\bar{\tau}^{c}})\right)+\frac{\bar{\Xi}\bar{\Pi}}{\bar{Y}}\sum_{s=0}^{T}\beta^{s}(E_{t}^{i}\hat{\Xi}_{t+s})\\
&-\left(\frac{\sigma}{\eta}\bar{w}\bar{s}(1-\bar{\tau}^{l})+(1+\bar{\tau}^{c})(1-\bar{g})\right)\bar{\Pi}\sum_{s=1}^{T}\beta^{s}\sum_{j=0}^{s-1}\frac{1}{\sigma}(E_{t}^{i}i_{t+j}-E_{t}^{i}\hat{\pi}_{t+j+1})\\
&-\left(\frac{\sigma}{\eta}\bar{w}\bar{s}(1-\bar{\tau}^{l})+(1+\bar{\tau}^{c})(1-\bar{g})\right)\bar{\Pi}\sum_{s=1}^{T}\beta^{s}\left(\frac{1}{\sigma}(E_{t}^{i}\xi_{t+s}-E_{t}^{i}\xi_{t}-\frac{E_{t}^{i}\tilde{\tau}_{t+s}^{c}-E_{t}^{i}\tilde{\tau}_{t}^{c}}{1+\bar{\tau}^{c}})\right)\\
&-(1-\bar{g})\bar{\Pi}\sum_{s=0}^{T}\beta^{s}\left(E_{t}^{i}\tilde{\tau}_{t+s}^{c}\right)+\bar{b}\sum_{s=0}^{T}\beta^{s}(\beta E_{t}^{i}\hat{i}_{t+s}-E_{t}^{i}\hat{\pi}_{t+s}) \qquad (49)\\
&-\beta^{T+1}\bar{b}\sum_{j=0}^{T-1}\frac{1}{\sigma}(E_{t}^{i}i_{t+j}-E_{t}^{i}\hat{\pi}_{t+j+1})-\beta^{T+1}\frac{\bar{b}}{\sigma}E_{t}^{i}i_{t+T}-\beta^{T+1}\frac{\bar{b}}{\sigma}(E_{t}^{i}\xi_{t+T+1}-E_{t}^{i}\xi_{t+T})-\beta^{T+1}\frac{\bar{b}}{\sigma}\frac{E_{t}^{i}\tilde{\tau}_{t+T}^{c}}{1+\bar{\tau}^{c}}
\end{aligned}
$$

Aggregating this equation over all households yields an expression for aggregate consumption as a function of aggregate expectations about aggregate variables, only.

$$
\begin{aligned}
&\left(\beta^{T+1}\bar{b}+\left(\frac{\sigma}{\eta}\bar{w}\bar{s}(1-\bar{\tau}^{l})+(1+\bar{\tau}^{c})(1-\bar{g})\right)\bar{\Pi}\frac{1-\beta^{T+1}}{1-\beta}\right)\hat{C}_{t}=\\
&\tilde{b}_{t}+\bar{w}\bar{s}\bar{\Pi}(1-\bar{\tau}^{l})\sum_{s=0}^{T}\beta^{s}\left((1+\frac{1}{\eta})(\bar{E}_{t}\hat{w}_{t+s}-\frac{\bar{E}_{t}\tilde{\tau}_{t+s}^{l}}{1-\bar{\tau}^{l}})+\frac{1}{\eta}(\bar{E}_{t}\xi_{t+s}-\frac{\bar{E}_{t}\tilde{\tau}_{t+s}^{c}}{1+\bar{\tau}^{c}})\right)+\frac{\bar{\Xi}\bar{\Pi}}{\bar{Y}}\sum_{s=0}^{T}\beta^{s}(\bar{E}_{t}\hat{\Xi}_{t+s})\\
&-\left(\frac{\sigma}{\eta}\bar{w}\bar{s}(1-\bar{\tau}^{l})+(1+\bar{\tau}^{c})(1-\bar{g})\right)\bar{\Pi}\sum_{s=1}^{T}\beta^{s}\sum_{j=0}^{s-1}\frac{1}{\sigma}(\bar{E}_{t}i_{t+j}-\bar{E}_{t}\hat{\pi}_{t+j+1})\\
&-\left(\frac{\sigma}{\eta}\bar{w}\bar{s}(1-\bar{\tau}^{l})+(1+\bar{\tau}^{c})(1-\bar{g})\right)\bar{\Pi}\sum_{s=1}^{T}\beta^{s}\left(\frac{1}{\sigma}(\bar{E}_{t}\xi_{t+s}-\bar{E}_{t}\xi_{t}-\frac{\bar{E}_{t}\tilde{\tau}_{t+s}^{c}-\bar{E}_{t}\tilde{\tau}_{t}^{c}}{1+\bar{\tau}^{c}})\right)\\
&-(1-\bar{g})\bar{\Pi}\sum_{s=0}^{T}\beta^{s}\left(\bar{E}_{t}\tilde{\tau}_{t+s}^{c}\right)+\bar{b}\sum_{s=0}^{T}\beta^{s}(\beta\bar{E}_{t}\hat{i}_{t+s}-\bar{E}_{t}\hat{\pi}_{t+s}) \qquad (50)\\
&-\beta^{T+1}\bar{b}\sum_{j=0}^{T-1}\frac{1}{\sigma}(\bar{E}_{t}i_{t+j}-\bar{E}_{t}\hat{\pi}_{t+j+1})-\beta^{T+1}\frac{\bar{b}}{\sigma}\bar{E}_{t}i_{t+T}-\beta^{T+1}\frac{\bar{b}}{\sigma}(\bar{E}_{t}\xi_{t+T+1}-\bar{E}_{t}\xi_{t+T})-\beta^{T+1}\frac{\bar{b}}{\sigma}\frac{\bar{E}_{t}\tilde{\tau}_{t+T}^{c}}{1+\bar{\tau}^{c}}
\end{aligned}
$$

B.2 Firms

Multiplying (15) by $\frac{\xi_t (C_t^j)^{-\sigma}}{(1+\tau_t^c)P_t} \frac{p_t^*(j)^{1+\theta}}{1-\theta}$ gives

$$\tilde{E}_t^j \sum_{s=0}^{T} \omega^s \beta^s \frac{\xi_{t+s}}{1+\tau_{t+s}^c} \left(C_{t+s}^j\right)^{-\sigma} \frac{Y_{t+s}}{P_{t+s}} \left[p_t^*(j) P_{t+s}^{\theta} - \frac{\theta}{\theta-1} mc_{t+s} P_{t+s}^{1+\theta} \right] = 0, \tag{51}$$

This can be written as

$$\begin{aligned} &\frac{p_t^*(j)}{P_t} \tilde{E}_t^j \sum_{s=0}^{T} \omega^s \beta^s \frac{\xi_{t+s}}{1+\tau_{t+s}^c} \left(C_{t+s}^j\right)^{-\sigma} \left(\frac{P_{t+s}}{P_t}\right)^{\theta-1} Y_{t+s} = \\ &\frac{\theta}{\theta-1} \tilde{E}_t^j \sum_{s=0}^{T} \omega^s \beta^s \frac{\xi_{t+s}}{1+\tau_{t+s}^c} \left(C_{t+s}^j\right)^{-\sigma} \left(\frac{P_{t+s}}{P_t}\right)^{\theta} Y_{t+s} mc_{t+s}, \end{aligned} \tag{52}$$

Finally, we can eliminate prices, and instead write the equation in terms of $d_t(j) = \frac{p_t^*(j)}{P_t}$ and in terms of inflation as

$$\begin{aligned} &d_t(j) \tilde{E}_t^j \sum_{s=0}^{T} \omega^s \beta^s \frac{\xi_{t+s}}{1+\tau_{t+s}^c} \left(C_{t+s}^j\right)^{-\sigma} \left(\prod_{j=1}^{s} \Pi_{t+j}\right)^{\theta-1} Y_{t+s} = \\ &\frac{\theta}{\theta-1} \tilde{E}_t^j \sum_{s=0}^{T} \omega^s \beta^s \frac{\xi_{t+s}}{1+\tau_{t+s}^c} \left(C_{t+s}^j\right)^{-\sigma} \left(\prod_{j=1}^{s} \Pi_{t+j}\right)^{\theta} Y_{t+s} mc_{t+s}, \end{aligned} \tag{53}$$

Log linearizing (53) gives

$$\begin{aligned} \hat{d}_t(j) =& \tilde{E}_t^j \sum_{s=0}^{T} \left(\frac{(c_1)^s}{s_1} - \frac{(c_2)^s}{s_2} \right) \left(\hat{Y}_{t+s} - \sigma \hat{C}_{t+s} - \frac{\tilde{\tau}_{t+s}^c}{1+\bar{\tau}^c} + \hat{\xi}_{t+s} \right) + \tilde{E}_t^j \sum_{s=0}^{T} \frac{(c_1)^s}{s_1} \hat{mc}_{t+s} \\ &+ \tilde{E}_t^j \sum_{s=1}^{T} \left(\theta \frac{(c_1)^s}{s_1} - (\theta-1) \frac{(c_2)^s}{s_2} \right) \sum_{i=1}^{s} \hat{\pi}_{t+i}, \end{aligned} \tag{54}$$

with

$$c_1 = \omega \beta \bar{\Pi}^{\theta} \tag{55}$$

$$c_2 = \omega \beta \bar{\Pi}^{\theta-1} \tag{56}$$

$$s_1 = \frac{1-\left(\omega\beta\bar{\Pi}^{\theta}\right)^{T+1}}{1-\omega\beta\bar{\Pi}^{\theta}} \tag{57}$$

$$s_2 = \frac{1-\left(\omega\beta\bar{\Pi}^{\theta-1}\right)^{T+1}}{1-\omega\beta\bar{\Pi}^{\theta-1}} \tag{58}$$

Aggregating (54) yields

$$\begin{aligned}\int_0^1 \hat{d}_t(j)\mathrm{d}j =& \bar{E}_t \sum_{s=0}^{T}\left(\frac{(c_1)^s}{s_1}-\frac{(c_2)^s}{s_2}\right)\left(\hat{Y}_{t+s}-\sigma\hat{C}_{t+s}-\frac{\tilde{\tau}^c_{t+s}}{1+\bar{\tau^c}}+\hat{\xi}_{t+s}\right)+\bar{E}_t\sum_{s=0}^{T}\frac{(c_1)^s}{s_1}\hat{mc}_{t+s} \\ &+\bar{E}_t\sum_{s=1}^{T}\left(\theta\frac{(c_1)^s}{s_1}-(\theta-1)\frac{(c_2)^s}{s_2}\right)\sum_{i=1}^{s}\hat{\pi}_{t+i},\end{aligned} \tag{59}$$

Next, I log linearize (17), and use this to write inflation as

$$\hat{\pi}_t = \frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\int_0^1 \hat{d}_t(j)\mathrm{d}j. \tag{60}$$

Plugging in (59) gives

$$\begin{aligned}\hat{\pi}_t =& \frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\Bigg[\bar{E}_t \sum_{s=0}^{T}\left(\frac{(c_1)^s}{s_1}-\frac{(c_2)^s}{s_2}\right)\left(\hat{Y}_{t+s}-\sigma\hat{C}_{t+s}-\frac{\tilde{\tau}^c_{t+s}}{1+\bar{\tau^c}}+\hat{\xi}_{t+s}\right)+\bar{E}_t\sum_{s=0}^{T}\frac{(c_1)^s}{s_1}\hat{mc}_{t+s} \\ &+\bar{E}_t\sum_{s=1}^{T}\left(\theta\frac{(c_1)^s}{s_1}-(\theta-1)\frac{(c_2)^s}{s_2}\right)\sum_{i=1}^{s}\hat{\pi}_{t+i}\Bigg]\end{aligned} \tag{61}$$

B.3 Final equations

To complete the model I first log-linearize the government budget constraint, (19), to

$$\tilde{b}_{t+1} = \frac{\bar{\Pi}}{\beta}\tilde{g}_t - \frac{\bar{w}\bar{s}\bar{\Pi}}{\beta}(\bar{\tau}^l(\hat{w}_t+\hat{H}_t)+\tilde{\tau}^l_t) - \frac{\bar{\Pi}}{\beta}(1-\bar{g})(\bar{\tau}^c\hat{C}_t+\tilde{\tau}^c_t)+\frac{1}{\beta}\tilde{b}_t+\bar{b}(\hat{i}_t-\frac{1}{\beta}\hat{\pi}_t), \tag{62}$$

Next, we can log linearize the market clearing condition, (20)

$$\hat{Y}_t = (1-\bar{g})\hat{C}_t + \tilde{g}_t, \tag{63}$$

Next, I turn to aggregate labor

$$H_t = \int_0^1 H_t(j)\mathrm{d}j = \int_0^1 Y_t(j)\mathrm{d}j = \int_0^1 \left(\frac{P_t(j)}{P_t}\right)^{-\theta} \mathrm{d}jY_t = s_t Y_t, \tag{64}$$

where $s_t = \int_0^1 \left(\frac{P_t(j)}{P_t}\right)^{-\theta} \mathrm{d}j$ is price dispersion in the economy in period t. Linearizing this equation and aggregating (47) wages and marginal costs can be written as

$$\begin{aligned} \hat{mc}_t = \hat{w}_t &= \eta\hat{H}_t + \sigma\hat{C}_t + \frac{\tilde{\tau}^c_t}{1+\bar{\tau}^c} + \frac{\tilde{\tau}^l_t}{1-\bar{\tau}^l} - \xi_t \\ &= (\eta + \frac{\sigma}{1-\bar{g}})\hat{Y}_t - \sigma\frac{\tilde{g}_t}{1-\bar{g}} + \frac{\tilde{\tau}^c_t}{1+\bar{\tau}^c} + \frac{\tilde{\tau}^l_t}{1-\bar{\tau}^l} + \eta\hat{s}_t - \xi_t \end{aligned} \tag{65}$$

Because all prices in the economy where set at different dates by the Calvo mechanism, price dispersion can be written as

$$\begin{aligned} s_t &= (1-\omega)\int_0^1 \left(\frac{p^*_t(j)}{P_t}\right)^{-\theta} \mathrm{d}j + \omega(1-\omega)\int_0^1 \left(\frac{p^*_{t-1}(j)}{P_t}\right)^{-\theta} \mathrm{d}j + \omega^2(1-\omega)\int_0^1 \left(\frac{p^*_{t-2}(j)}{P_t}\right)^{-\theta} \mathrm{d}j + ... \\ &= (1-\omega)\sum_{i=0}^{\infty}\omega^i \int_0^1 \left(\frac{p^*_{t-i}(j)}{P_t}\right)^{-\theta} \mathrm{d}j \end{aligned} \tag{66}$$

We can therefore write price dispersion as

$$\begin{aligned} s_t &= (1-\omega)\int_0^1 \left(\frac{p^*_t(j)}{P_t}\right)^{-\theta} \mathrm{d}j + \omega\Pi^\theta_t(1-\omega)\sum_{i=0}^{\infty}\omega^i \int_0^1 \left(\frac{p^*_{t-1-i}(j)}{P_{t-1}}\right)^{-\theta} \mathrm{d}j \\ &= (1-\omega)\int_0^1 d_t(j)^{-\theta}\mathrm{d}j + \omega\Pi^\theta_t s_{t-1} \end{aligned} \tag{67}$$

Price dispersion is log linearized to

$$\hat{s}_t = -\theta(1-\omega\bar{\Pi}^\theta)\int_0^1 \hat{d}_t(j)\mathrm{d}j + \theta\omega\bar{\Pi}^\theta\hat{\pi}_t + \omega\bar{\Pi}^\theta\hat{s}_{t-1} \tag{68}$$

Using (60), this can be written as

$$\hat{s}_t = \frac{\theta\omega\bar{\Pi}^{\theta-1}}{1-\omega\bar{\Pi}^{\theta-1}}(\bar{\Pi}-1)\hat{\pi}_t + \omega\bar{\Pi}^{\theta}\hat{s}_{t-1} \tag{69}$$

Finally, we can write real aggregate firm profits as

$$\Xi_t = \int_0^1 \Xi_t(j)\mathrm{d}j = \int_0^1 Y_t(j)\frac{P_t(j)}{P_t} - mc_t Y_t(j)\mathrm{d}j = (1 - mc_t s_t)Y_t, \tag{70}$$

which can be log-linearized to

$$\hat{\Xi}_t = \hat{Y}_t - \frac{\bar{s}\bar{w}}{1-\bar{s}\bar{w}}\left(\hat{mc}_t + \hat{s}_t\right). \tag{71}$$

Using (20) in (50) results an expression for aggregate output.

$$\begin{aligned}
\hat{Y}_t = {} & \frac{1}{\rho}\tilde{b}_t + g_t + \delta\sum_{s=0}^{T}\beta^s((1-\bar{\tau}^l)\bar{E}_t\hat{w}_{t+s} - \bar{E}_t\tilde{\tau}^l_{t+s}) + \frac{(1-\bar{w}\bar{s})\bar{\Pi}}{\rho}\sum_{s=0}^{T}\beta^s(\bar{E}_t\hat{\Xi}_{t+s}) \\
& - \mu\sum_{s=1}^{T}\beta^s\sum_{j=0}^{s-1}(\bar{E}_t i_{t+j} - \bar{E}_t\hat{\pi}_{t+j+1}) + \frac{\bar{b}}{\rho}\sum_{s=0}^{T}\beta^s(\beta\bar{E}_t\hat{i}_{t+s} - \bar{E}_t\hat{\pi}_{t+s}) \\
& - \beta^{T+1}\frac{\bar{b}}{\sigma\rho}\sum_{j=0}^{T-1}(\bar{E}_t i_{t+j} - \bar{E}_t\hat{\pi}_{t+j+1}) - \beta^{T+1}\frac{\bar{b}}{\sigma\rho}\bar{E}_t i_{t+T} \\
& + \delta_\xi\xi_t - \mu_\xi\sum_{s=1}^{T}\beta^s(\bar{E}_t\xi_{t+s} - \xi_t) - \beta^{T+1}\frac{\bar{b}}{\sigma\rho}(\bar{E}_t\xi_{t+T+1} - \bar{E}_t\xi_{t+T}) \\
& - \frac{\delta_\xi}{1+\bar{\tau}^c}\tilde{\tau}^c_t - \frac{\bar{\Pi}(1-\bar{g})}{\rho}\sum_{s=0}^{T}\beta^s\bar{E}_t\tilde{\tau}^c_{t+s} + \frac{\bar{\Pi}(1-\bar{g})}{\rho\sigma}\sum_{s=1}^{T}\beta^s(\bar{E}_t\tilde{\tau}^c_{t+s} - \bar{E}_t\tilde{\tau}^c_t) - \beta^{T+1}\frac{\bar{b}}{\sigma\rho}\frac{\bar{E}_t\tilde{\tau}^c_{t+T}}{1+\bar{\tau}^c}
\end{aligned} \tag{72}$$

$$\delta = \frac{\bar{w}\bar{s}\bar{\Pi}}{\rho}\frac{\eta+1}{\eta} \tag{73}$$

$$\delta_\xi = \frac{1-\beta^{T+1}}{1-\beta}\frac{\bar{w}\bar{s}\bar{\Pi}}{\rho}\frac{1-\bar{\tau}^l}{\eta} \tag{74}$$

$$\mu = \frac{\bar{\Pi}}{\rho}\left(\frac{\bar{w}\bar{s}}{\eta}(1-\bar{\tau}^l) + (1+\bar{\tau}^c)\frac{1-\bar{g}}{\sigma}\right) \tag{75}$$

$$\mu_{\xi} = \frac{\bar{\Pi}}{\rho}(1+\bar{\tau}^c)\frac{1-\bar{g}}{\sigma} \tag{76}$$

$$\rho = \frac{1}{1-\bar{g}}\left[\beta^{T+1}\bar{b} + \left(\frac{\sigma}{\eta}\bar{w}\bar{s}(1-\bar{\tau}^l) + (1+\bar{\tau}^c)(1-\bar{g})\right)\bar{\Pi}\frac{1-\beta^{T+1}}{1-\beta}\right] \tag{77}$$

I now assume that agents know, or have learned about the above relations between aggregate variables (which hold in every period). Therefore, expectations about wages and profits can be substituted for, using (65) and (71). This gives the following system of 3 equations that, together with a specification of monetary and fiscal policy and price dispersion, completely describe our model

$$\begin{aligned}
(1-\nu_y)\hat{Y}_t = & \frac{1}{\rho}\tilde{b}_t + g_t + \nu_\tau \sum_{s=0}^{T} \beta^s (\bar{E}_t \hat{\tau}^l_{t+s}) + \nu_g \sum_{s=0}^{T} \beta^s (\bar{E}_t \hat{g}_{t+s}) + \nu_y \sum_{s=1}^{T} \beta^s (\bar{E}_t \hat{Y}_{t+s}) \\
& + \nu_s \sum_{j=0}^{T} \beta^j (\bar{E}_t \hat{s}_{t+j}) - \mu \sum_{s=1}^{T} \beta^s \sum_{j=1}^{s} (\bar{E}_t i_{t+j-1} - \bar{E}_t \hat{\pi}_{t+j}) + \frac{\bar{b}}{\rho} \sum_{s=0}^{T} \beta^s (\beta \bar{E}_t \hat{i}_{t+s} - \bar{E}_t \hat{\pi}_{t+s}) \\
& - \beta^{T+1} \frac{\bar{b}}{\sigma\rho} \sum_{j=0}^{T-1} (\bar{E}_t i_{t+j} - \bar{E}_t \hat{\pi}_{t+j+1}) - \beta^{T+1} \frac{\bar{b}}{\sigma\rho} \bar{E}_t i_{t+T} \\
& + \delta_\xi \xi_t + \nu_\xi \sum_{s=0}^{T} \beta^s \bar{E}_t \tilde{\xi}_{t+s} - \mu_\xi \sum_{s=1}^{T} \beta^s (\bar{E}_t \xi_{t+s} - \xi_t) - \beta^{T+1} \frac{\bar{b}}{\sigma\rho} (\bar{E}_t \xi_{t+T+1} - \bar{E}_t \xi_{t+T}) \\
& - \frac{\delta_\xi}{1+\bar{\tau}^c} \tilde{\tau}^c_t + \nu_c \sum_{s=0}^{T} \beta^s \bar{E}_t \tilde{\tau}^c_{t+s} + \frac{\bar{\Pi}(1-\bar{g})}{\rho\sigma} \sum_{s=1}^{T} \beta^s (\bar{E}_t \tilde{\tau}^c_{t+s} - \bar{E}_t \tilde{\tau}^c_t) - \beta^{T+1} \frac{\bar{b}}{\sigma\rho} \frac{\bar{E}_t \tilde{\tau}^c_{t+T}}{1+\bar{\tau}^c}
\end{aligned} \tag{78}$$

$$\begin{aligned}
\hat{\pi}_t = & \bar{E}_t \sum_{s=0}^{T} \left(\kappa_{y1}(c_1)^s + \kappa_{y2}(c_2)^s\right) \hat{Y}_{t+s} + \kappa_g \bar{E}_t \sum_{s=0}^{T} (c_2)^s \tilde{g}_{t+s} + \kappa_s \bar{E}_t \sum_{s=0}^{T} (c_1)^s \hat{s}_{t+s} \\
& + \kappa_c \bar{E}_t \sum_{s=0}^{T} (c_2)^s \tilde{\tau}^c_{t+s} + \kappa_\tau \bar{E}_t \sum_{s=0}^{T} (c_1)^s \tilde{\tau}^l_{t+s} + \bar{E}_t \sum_{s=1}^{T} \left(\kappa_{\pi1}(c_1)^s + \kappa_{\pi2}(c_2)^s\right) \sum_{i=1}^{s} \hat{\pi}_{t+i} \\
& + \kappa_\xi \bar{E}_t \sum_{s=0}^{T} (c_2)^s \hat{\xi}_{t+s}
\end{aligned} \tag{79}$$

$$
\begin{aligned}
\tilde{b}_{t+1} =& \frac{\bar{\Pi}}{\beta}\tilde{g}_t - \frac{\bar{\Pi}}{\beta}\bar{\tau}^c(\hat{Y}_t - \tilde{g}_t) - \frac{\bar{\Pi}}{\beta}(1-\bar{g})\tilde{\tau}^c_t + \frac{1}{\beta}\tilde{b}_t + \bar{b}(\hat{i}_t - \frac{1}{\beta}\hat{\pi}_t) \\
&- \frac{\bar{w}\bar{s}\bar{\Pi}}{\beta}\left[\bar{\tau}^l\left((1+\eta+\frac{\sigma}{1-\bar{g}})\hat{Y}_t - \sigma\frac{\tilde{g}_t}{1-\bar{g}} + \frac{\tilde{\tau}^c_t}{1+\bar{\tau}^c} + \frac{\tilde{\tau}^l_t}{1-\bar{\tau}^l} + (1+\eta)\hat{s}_t - \xi_t\right) + \tilde{\tau}^l_t\right],
\end{aligned} \tag{80}
$$

with

$$\nu_y = \frac{(1-\bar{s}\bar{w})\bar{\Pi}}{\rho} + \left(\delta(1-\bar{\tau}^l) - \frac{\bar{s}\bar{w}\bar{\Pi}}{\rho}\right)(\eta + \frac{\sigma}{1-\bar{g}}), \tag{81}$$

$$\nu_g = \left(\frac{\bar{s}\bar{w}\bar{\Pi}}{\rho} - \delta(1-\bar{\tau}^l)\right)\frac{\sigma}{1-\bar{g}}, \tag{82}$$

$$\nu_\tau = -\frac{\bar{s}\bar{w}\bar{\Pi}}{\rho(1-\bar{\tau}^l)}, \tag{83}$$

$$\nu_s = -\frac{\bar{s}\bar{w}\bar{\Pi}}{\rho}(\eta+1)\bar{\tau}^l, \tag{84}$$

$$\nu_\xi = \frac{\bar{s}\bar{w}\bar{\Pi}}{\rho} - \delta(1-\bar{\tau}^l), \tag{85}$$

$$\nu_c = \delta\frac{1-\bar{\tau}^l}{1+\bar{\tau}^c} - \frac{\bar{s}\bar{w}\bar{\Pi}}{\rho(1+\bar{\tau}^c)} - \frac{\Pi}{\rho}(1-\bar{g}), \tag{86}$$

$$\kappa_{y1} = \frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\frac{1+\eta}{s_1} \tag{87}$$

$$\kappa_{y2} = -\frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\frac{1-\frac{\sigma}{1-\bar{g}}}{s_2} \tag{88}$$

$$\kappa_g = -\frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\frac{\sigma}{(1-\bar{g})s_2} \tag{89}$$

$$\kappa_s = \frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\frac{\eta}{s_1} \tag{90}$$

$$\kappa_c = \frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\frac{1}{(1+\bar{\tau}^c)s_2} \tag{91}$$

$$\kappa_\tau = \frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\frac{1}{(1-\bar{\tau})s_1} \tag{92}$$

$$\kappa_{\pi 1} = \frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\frac{\theta}{s_1} \tag{93}$$

$$\kappa_{\pi 2} = -\frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\frac{\theta-1}{s_2} \tag{94}$$

$$\kappa_{\xi} = -\frac{1-\omega\bar{\Pi}^{\theta-1}}{\omega\bar{\Pi}^{\theta-1}}\frac{1}{s_2} \tag{95}$$

B.4 Zero inflation target

In case of $\bar{\Pi} = 0$ the above model reduces to

$$(1-\nu_{y0})\hat{Y}_t = \frac{1}{\rho_0}\tilde{b}_t + g_t + \nu_{\tau 0}\sum_{s=0}^{T}\beta^s(\bar{E}_t\hat{\tau}^l_{t+s}) + \nu_{g0}\sum_{s=0}^{T}\beta^s(\bar{E}_t\hat{g}_{t+s}) + \nu_{y0}\sum_{s=1}^{T}\beta^s(\bar{E}_t\hat{Y}_{t+s}) \tag{96}$$

$$\begin{aligned}
&- \mu_0\sum_{s=1}^{T}\beta^s\sum_{j=1}^{s}(\bar{E}_t i_{t+j-1} - \bar{E}_t\hat{\pi}_{t+j}) + \frac{\bar{b}}{\rho_0}\sum_{s=0}^{T}\beta^s(\beta\bar{E}_t\hat{i}_{t+s} - \bar{E}_t\hat{\pi}_{t+s})\\
&- \beta^{T+1}\frac{\bar{b}}{\sigma\rho_0}\sum_{j=0}^{T-1}(\bar{E}_t i_{t+j} - \bar{E}_t\hat{\pi}_{t+j+1}) - \beta^{T+1}\frac{\bar{b}}{\sigma\rho_0}\bar{E}_t i_{t+T}\\
&+ \delta_{\xi 0}\xi_t + \nu_{\xi 0}\sum_{s=0}^{T}\beta^s\bar{E}_t\tilde{\xi}_{t+s} - \mu_{\xi 0}\sum_{s=1}^{T}\beta^s(\bar{E}_t\xi_{t+s} - \xi_t) - \beta^{T+1}\frac{\bar{b}}{\sigma\rho_0}(\bar{E}_t\xi_{t+T+1} - \bar{E}_t\xi_{t+T})\\
&- \frac{\delta_{\xi 0}}{1+\bar{\tau}^c}\tilde{\tau}^c_t + \nu_{c0}\sum_{s=0}^{T}\beta^s\bar{E}_t\tilde{\tau}^c_{t+s} + \frac{(1-\bar{g})}{\rho_0\sigma}\sum_{s=1}^{T}\beta^s(\bar{E}_t\tilde{\tau}^c_{t+s} - \bar{E}_t\tilde{\tau}^c_t) - \beta^{T+1}\frac{\bar{b}}{\sigma\rho}\frac{\bar{E}_t\tilde{\tau}^c_{t+T}}{1+\bar{\tau}^c}
\end{aligned}$$

$$\begin{aligned}
\hat{\pi}_t =& \tilde{\kappa}(\eta + \frac{\sigma}{1-\bar{g}})\sum_{s=0}^{T}\omega^s\beta^s\hat{E}_t\hat{Y}_{t+s} - \frac{\tilde{\kappa}\sigma}{1-\bar{g}}\sum_{s=0}^{T}\omega^s\beta^s\hat{E}_t\tilde{g}_{t+s}\\
&+ \frac{\tilde{\kappa}}{1+\bar{\tau}^c}\sum_{s=0}^{T}\omega^s\beta^s\hat{E}_t\tilde{\tau}^c_{t+s} + \frac{\tilde{\kappa}}{1-\bar{\tau}^l}\sum_{s=0}^{T}\omega^s\beta^s\hat{E}_t\tilde{\tau}^l_{t+s} + \tilde{\kappa}\sum_{s=1}^{T}\omega^s\beta^s\sum_{\tau=1}^{s}\hat{E}_t\hat{\pi}_{t+\tau},
\end{aligned} \tag{97}$$

$$\tilde{b}_{t+1} = \frac{1}{\beta}\tilde{g}_t - \frac{\bar{\tau}^c}{\beta}(\hat{Y}_t - \tilde{g}_t) - \frac{1-\bar{g}}{\beta}\tilde{\tau}^c_t + \frac{1}{\beta}\tilde{b}_t + \bar{b}(\hat{i}_t - \frac{1}{\beta}\hat{\pi}_t) \\ - \frac{\bar{w}}{\beta}\left[\bar{\tau}^l\left((1+\eta+\frac{\sigma}{1-\bar{g}})\hat{Y}_t - \sigma\frac{\tilde{g}_t}{1-\bar{g}} + \frac{\tilde{\tau}^c_t}{1+\bar{\tau}^c} + \frac{\tilde{\tau}^l_t}{1-\bar{\tau}^l} - \xi_t\right) + \tilde{\tau}^l_t\right], \tag{98}$$

$$\delta_0 = \frac{\bar{w}}{\rho_0}\frac{\eta+1}{\eta}, \tag{99}$$

$$\mu_0 = \frac{1}{\rho_0}\left(\frac{\bar{w}}{\eta}(1-\bar{\tau}^l) + (1+\bar{\tau}^c)\frac{1-\bar{g}}{\sigma}\right), \tag{100}$$

$$\delta_\xi = \frac{1-\beta^{T+1}}{1-\beta}\frac{\bar{w}}{\rho_0}\frac{1-\bar{\tau}^l}{\eta} \tag{101}$$

$$\mu_\xi = \frac{1}{\rho_0}(1+\bar{\tau}^c)\frac{1-\bar{g}}{\sigma} \tag{102}$$

$$\rho_0 = \frac{1}{1-\bar{g}}\left[\beta^{T+1}\bar{b} + \left(\frac{\sigma}{\eta}\bar{w}(1-\bar{\tau}^l) + (1+\bar{\tau}^c)(1-\bar{g})\right)\frac{1-\beta^{T+1}}{1-\beta}\right]. \tag{103}$$

$$\nu_{y0} = \frac{1-\bar{w}}{\rho} + \left(\delta(1-\bar{\tau}^l) - \frac{\bar{w}}{\rho_0}\right)(\eta + \frac{\sigma}{1-\bar{g}}), \tag{104}$$

$$\nu_{g0} = \left(\frac{\bar{w}}{\rho_0} - \delta_0(1-\bar{\tau}^l)\right)\frac{\sigma}{1-\bar{g}}, \tag{105}$$

$$\nu_{\tau 0} = -\frac{\bar{w}}{\rho_0(1-\bar{\tau}^l)}, \tag{106}$$

$$\nu_{\xi 0} = \frac{\bar{w}}{\rho_0} - \delta_0(1-\bar{\tau}^l), \tag{107}$$

$$\nu_{c0} = \delta_0\frac{1-\bar{\tau}^l}{1+\bar{\tau}^c} - \frac{\bar{w}}{\rho_0(1+\bar{\tau}^c)} - \frac{(1-\bar{g})}{\rho_0}, \tag{108}$$

$$\tilde{\kappa} = \frac{(1-\omega)(1-\omega\beta)}{\omega(1-\omega^{T+1}\beta^{T+1})}. \tag{109}$$

C Model under infinitely forward looking expectations

C.1 Output

When we let the planning horizon, T, go to infinity (72) can be written as

$$
\begin{aligned}
&\hat{Y}_t = \frac{1}{\rho}\tilde{b}_t + g_t + \delta\sum_{s=0}^{\infty}\beta^s((1-\bar{\tau}^l)((1-\alpha)E_t^F\hat{w}_{t+s} + \alpha E_t^b\hat{w}_{t+s}) - (1-\alpha)E_t^F\tilde{\tau}^l_{t+s} - \alpha E_t^b\tilde{\tau}^l_{t+s})+ \\
&\frac{(1-\bar{w}\bar{s})\bar{\Pi}}{\rho}\sum_{s=0}^{\infty}\beta^s((1-\alpha)E_t^F\hat{\Xi}_{t+s} + \alpha E_t^b\hat{\Xi}_{t+s}) + \left(\delta_\xi + \frac{\mu_\xi\beta}{1-\beta}\right)\xi_t - \mu_\xi\sum_{s=1}^{\infty}\beta^s((1-\alpha)E_t^F\hat{\xi}_{t+s} + \alpha E_t^b\hat{\xi}_{t+s}) \\
&-\left(\frac{\delta_\xi}{1+\bar{\tau}^c} + \left(\frac{\beta}{(1-\beta)\sigma}+1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi}\right)\tilde{\tau}^c_t + \left(\frac{1}{\sigma}-1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi}\sum_{s=1}^{\infty}\beta^s((1-\alpha)E_t^F\tilde{\tau}^c_{t+s} + \alpha E_t^b\tilde{\tau}^c_{t+s}) \\
&-\frac{\mu\beta}{1-\beta}\sum_{s=0}^{\infty}\beta^s(((1-\alpha)E_t^F\hat{i}_{t+s} + \alpha E_t^b\hat{i}_{t+s}) - ((1-\alpha)E_t^F\hat{\pi}_{t+s+1} + \alpha E_t^b\hat{\pi}_{t+s+1})) \\
&+\frac{\bar{b}}{\rho}\sum_{s=0}^{\infty}\beta^s(\beta((1-\alpha)E_t^F\hat{i}_{t+s} + \alpha E_t^b\hat{i}_{t+s}) - ((1-\alpha)E_t^F\hat{\pi}_{t+s} + \alpha E_t^b\hat{\pi}_{t+s}))
\end{aligned}
$$

Leading this equation 1 period and taking forward looking expectations gives

$$
\begin{aligned}
&E_t^F\hat{Y}_{t+1} = \delta\sum_{s=1}^{\infty}\beta^{s-1}((1-\bar{\tau}^l)((1-\alpha)E_t^F\hat{w}_{t+s} + \alpha E_t^F E_{t+1}^b\hat{w}_{t+s}) - (1-\alpha)E_t^F\tilde{\tau}^l_{t+s} - \alpha E_t^F E_{t+1}^b\tilde{\tau}^l_{t+s})+ \\
&E_t^F g_{t+1} + \frac{1}{\rho}\tilde{b}_{t+1} + \frac{(1-\bar{w}\bar{s})\bar{\Pi}}{\rho}\sum_{s=1}^{\infty}\beta^{s-1}((1-\alpha)E_t^F\hat{\Xi}_{t+s} + \alpha E_t^F E_{t+1}^b\hat{\Xi}_{t+s}) \\
&+\left(\delta_\xi + \frac{\mu_\xi\beta}{1-\beta}\right)E_t^F\hat{\xi}_{t+1} - \mu_\xi\sum_{s=2}^{\infty}\beta^{s-1}((1-\alpha)E_t^F\hat{\xi}_{t+s} + \alpha E_t^F E_{t+1}^b\hat{\xi}_{t+s}) \\
&-\left(\frac{\delta_\xi}{1+\bar{\tau}^c} + \left(\frac{\beta}{(1-\beta)\sigma}+1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi}\right)E_t^F\tilde{\tau}^c_{t+1} + \left(\frac{1}{\sigma}-1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi}\sum_{s=2}^{\infty}\beta^{s-1}((1-\alpha)E_t^F\tilde{\tau}^c_{t+s} + \alpha E_t^F E_{t+1}^b\tilde{\tau}^c_{t+} \\
&-\frac{\mu\beta}{1-\beta}\sum_{s=1}^{\infty}\beta^{s-1}(((1-\alpha)E_t^F\hat{i}_{t+s} + \alpha E_t^F E_{t+1}^b\hat{i}_{t+s}) - ((1-\alpha)E_t^F\hat{\pi}_{t+s+1} + \alpha E_t^F E_{t+1}^b\hat{\pi}_{t+s+1})) \\
&+\frac{\bar{b}}{\rho}\sum_{s=1}^{\infty}\beta^{s-1}(\beta((1-\alpha)E_t^F\hat{i}_{t+s} + \alpha E_t^F E_{t+1}^b\hat{i}_{t+s}) - ((1-\alpha)E_t^F\hat{\pi}_{t+s} + \alpha E_t^F E_{t+1}^b\hat{\pi}_{t+s}))
\end{aligned}
$$

Under the assumption (maintained throughout the main body of the paper) that $E_t^F E_{t+1}^b \hat{x}_{t+s} = E_t^b \hat{x}_{t+s}$ for $1 < s \leq T$, and plugging in backward-looking expectations and wages and profits, output can be written recursively as

$$
\begin{aligned}
&(1-\nu_y)\hat{Y}_t = (\beta - \alpha\beta\nu_y)E_t^f \hat{Y}_{t+1} + \alpha\beta d^2 \nu_y \hat{Y}_{t-1} + \frac{1}{\rho}(\tilde{b}_t - \beta\tilde{b}_{t+1}) + (1+\nu_g)\tilde{g}_t - (\beta + \alpha\beta\nu_g)E_t^f \tilde{g}_{t+1} \\
&+ \alpha\beta d^2 \nu_g \tilde{g}_{t-1} + \nu_\tau(\tilde{\tau}_t^l + \alpha\beta(d^2\tilde{\tau}_{t-1}^l - E_t^f \tilde{\tau}_{t+1}^l)) + \nu_s(\hat{s}_t + \alpha\beta(d^2\hat{s}_{t-1} - E_t^f \hat{s}_{t+1})) \\
&+ \left(\delta_\xi + \frac{\mu_\xi\beta}{1-\beta} + \nu_\xi\right)\hat{\xi}_t - \left(\beta\delta_\xi + \beta\frac{\mu_\xi\beta}{1-\beta} + \mu_\xi\beta(1-\alpha) + \alpha\beta\nu_\xi\right)E_t^f \hat{\xi}_{t+1} \\
&- \left(\frac{\delta_\xi}{1+\bar{\tau}^c} + \left(\frac{\beta}{(1-\beta)\sigma} + 1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi} - \nu_c\right)\tilde{\tau}_t^c + \left(\left(\frac{1}{\sigma} - 1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi} + \nu_c\right)\alpha\beta d^2 \tilde{\tau}_{t-1}^c \\
&+ \beta\left(\frac{\delta_\xi}{1+\bar{\tau}^c} + \left(\frac{\beta}{(1-\beta)\sigma} + 1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi} + \left(\frac{1}{\sigma} - 1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi}(1-\alpha) - \alpha\nu_c\right)E_t^f \tilde{\tau}_{t+1}^c \\
&+ (\frac{\mu\beta}{1-\beta}(1-\alpha) + \alpha\beta\frac{\bar{b}}{\rho})E_t^F \hat{\pi}_{t+1} + (\frac{\mu\beta}{1-\beta}\alpha d^2 - \alpha\beta\frac{\bar{b}}{\rho}d^2)\hat{\pi}_{t-1} - \frac{\bar{b}}{\rho}\hat{\pi}_t + (\frac{\bar{b}\beta}{\rho} - \frac{\mu\beta}{1-\beta})(\hat{i}_t + \alpha\beta(d^2\hat{i}_{t-1} - E_t^f \hat{i}_{t+
\end{aligned}
$$

where I follow the assumption that all agents can observe contemporaneous variables when making their decision (but not yet when forming expectations), and the assumption that backward-looking agents do not anticipate future shocks.

C.2 Inflation

When T goes to infinity, (79) can be written as

$$
\begin{aligned}
\hat{\pi}_t =& \psi_t + \kappa_{y1}\sum_{s=0}^{\infty}(c_1)^s((1-\alpha)E_t^F \hat{Y}_{t+s} + \alpha E_t^b \hat{Y}_{t+s}) \\
& \kappa_s \sum_{s=0}^{\infty}(c_1)^s((1-\alpha)E_t^F \hat{s}_{t+s} + \alpha E_t^b \hat{s}_{t+s}) + \kappa_\tau \sum_{s=0}^{\infty}(c_1)^s((1-\alpha)E_t^F \tilde{\tau}_{t+s} + \alpha E_t^b \tilde{\tau}_{t+s}) \\
& + \frac{\kappa_{\pi 1}}{1-c_1}\sum_{s=1}^{\infty}(c_1)^s((1-\alpha)E_t^F \hat{\pi}_{t+s} + \alpha E_t^b \hat{\pi}_{t+s})
\end{aligned} \tag{110}
$$

with

$$
\begin{aligned}
\psi_t =& \kappa_{y2}\sum_{s=0}^{\infty}(c_2)^s((1-\alpha)E_t^F\hat{Y}_{t+s}+\alpha E_t^b\hat{Y}_{t+s})+\kappa_g\sum_{s=0}^{\infty}(c_2)^s((1-\alpha)E_t^F\tilde{g}_{t+s}+\alpha E_t^b\tilde{g}_{t+s}) \qquad (111)\\
&+\kappa_c\sum_{s=0}^{\infty}(c_2)^s((1-\alpha)E_t^F\tilde{\tau}^c_{t+s}+\alpha E_t^b\tilde{\tau}^c_{t+s})+\kappa_\xi\sum_{s=0}^{\infty}(c_2)^s((1-\alpha)E_t^F\hat{\xi}_{t+S}+\alpha E_t^b\hat{\xi}_{t+s})\\
&+\frac{\kappa_{\pi 2}}{1-c_2}\sum_{s=1}^{\infty}(c_2)^s((1-\alpha)E_t^F\hat{\pi}_{t+s}+\alpha E_t^b\hat{\pi}_{t+s})
\end{aligned}
$$

Writing one period ahead an taking forward-looking expectations gives

$$
\begin{aligned}
E_t^F\hat{\pi}_{t+1} =& E_t^F\psi_{t+1}+\kappa_{y1}\sum_{s=1}^{\infty}(c_1)^{s-1}((1-\alpha)E_t^F\hat{Y}_{t+s}+\alpha E_t^F E_{t+1}^b\hat{Y}_{t+s}) \qquad (112)\\
&+\kappa_s\sum_{s=1}^{\infty}(c_1)^{s-1}((1-\alpha)E_t^F\hat{s}_{t+s}+\alpha E_t^F E_{t+1}^b\hat{s}_{t+s})+\kappa_\tau\sum_{s=1}^{\infty}(c_1)^{s-1}((1-\alpha)E_t^F\tilde{\tau}_{t+s}+\alpha E_t^F E_{t+1}^b\tilde{\tau}_{t+s})\\
&+\frac{\kappa_{\pi 1}}{1-c_1}\sum_{s=2}^{\infty}(c_1)^{s-1}((1-\alpha)E_t^F\hat{\pi}_{t+s}+\alpha E_t^F E_{t+1}^b\hat{\pi}_{t+s})
\end{aligned}
$$

$$
\begin{aligned}
E_t^F\psi_{t+1} =& \kappa_{y2}\sum_{s=1}^{\infty}(c_2)^{s-1}((1-\alpha)E_t^F\hat{Y}_{t+s}+\alpha E_t^b\hat{Y}_{t+s})+\kappa_g\sum_{s=1}^{\infty}(c_2)^{s-1}((1-\alpha)E_t^F\tilde{g}_{t+s}+\alpha E_t^b\tilde{g}_{t+s})\\
&+\kappa_c\sum_{s=1}^{\infty}(c_2)^{s-1}((1-\alpha)E_t^F\tilde{\tau}^c_{t+s}+\alpha E_t^b\tilde{\tau}^c_{t+s})+\kappa_\xi\sum_{s=1}^{\infty}(c_2)^{s-1}((1-\alpha)E_t^F\hat{\xi}_{t+s}+\alpha E_t^b\hat{\xi}_{t+s})\\
&+\frac{\kappa_{\pi 2}}{1-c_2}\sum_{s=2}^{\infty}(c_2)^{s-1}((1-\alpha)E_t^F\hat{\pi}_{t+s}+\alpha E_t^b\hat{\pi}_{t+s}) \qquad (113)
\end{aligned}
$$

Plugging in expectations of backward-looking agents we can write

$$
\begin{aligned}
\hat{\pi}_t =& c_1E_t^F\hat{\pi}_{t+1}+\psi_t-c_1E_t^F\psi_{t+1}+\kappa_{y1}(\hat{Y}_t+\alpha c_1(d^2\hat{Y}_{t-1}-E_t^f\hat{Y}_{t+1})) \qquad (114)\\
&\kappa_s(\hat{s}_t+\alpha c_1(d^2\hat{s}_{t-1}-E_t^f\hat{s}_{t+1}))+\kappa_\tau(\tilde{\tau}^l_t+\alpha c_1(d^2\tilde{\tau}^l_{t-1}-E_t^f\tilde{\tau}^l_{t+1}))\\
&+\frac{c_1\kappa_{\pi 1}}{1-c_1}((1-\alpha)E_t^F\hat{\pi}_{t+1}+\alpha E_t^b\hat{\pi}_{t+1})
\end{aligned}
$$

and

$$\begin{aligned}\psi_t =& c_2 E_t^F \psi_{t+1} + \kappa_{y2}(\hat{Y}_t + \alpha c_2(d^2\hat{Y}_{t-1} - E_t^f \hat{Y}_{t+1})) \\ &+ \kappa_g(\tilde{g}_t + \alpha c_2(d^2\tilde{g}_{t-1} - E_t^f \tilde{g}_{t+1})) + \kappa_c(\tilde{\tau}_t^c + \alpha c_2(d^2\tilde{\tau}_{t-1}^c - E_t^f \tilde{\tau}_{t+1}^c)) \\ &+ \frac{c_2\kappa_{\pi 2}}{1-c_2}((1-\alpha)E_t^F\hat{\pi}_{t+1} + \alpha E_t^b \hat{\pi}_{t+1}) + \kappa_\xi(\hat{\xi}_t - \alpha c_2 E_t^f \hat{\xi}_{t+1})\end{aligned} \tag{115}$$

C.3 Fully rational expectations

Now, I consider the robustness of the assumption that forward-looking agents do not anticipate how backward-looking agents will revise their expectations in future periods. In case of an infinite planning horizon, forward-looking agents become fully rational when they take account of how backward-looking agents will revise their expectations.

Following similar steps as above, output and inflation can then be written recursively as

$$\begin{aligned}(1-z_1\nu_y)\hat{Y}_t =& (\beta - \alpha\beta\nu_y)E_t^f\hat{Y}_{t+1} + z_2\nu_y\hat{Y}_{t-1} + \frac{1}{\rho}(\tilde{b}_t - \beta\tilde{b}_{t+1}) + (1+z_1\nu_g)\tilde{g}_t - (\beta + \alpha\beta\nu_g)E_t^f\tilde{g}_{t+1} \\ &+ z_2\nu_g\tilde{g}_{t-1} + \nu_\tau(z_1\tilde{\tau}_t^l + z_2\tilde{\tau}_{t-1}^l - \alpha\beta E_t^f\tilde{\tau}_{t+1}^l) + \nu_s(z_1\hat{s}_t + z_2\hat{s}_{t-1} - \alpha\beta E_t^f\hat{s}_{t+1})) \\ &+ \left(\delta_\xi + \frac{\mu_\xi\beta}{1-\beta} + \nu_\xi\right)\hat{\xi}_t - \left(\beta\delta_\xi + \beta\frac{\mu_\xi\beta}{1-\beta} + \mu_\xi\beta(1-\alpha) + \alpha\beta\nu_\xi\right)E_t^f\hat{\xi}_{t+1} \\ &- \left(\frac{\delta_\xi}{1+\bar{\tau}^c} + \left(\frac{\beta}{(1-\beta)\sigma} + 1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi} + \alpha\frac{\beta^2 d^2}{1-\beta d}\left(\frac{1}{\sigma} - 1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi} - z_1\nu_c\right)\tilde{\tau}_t^c \\ &+ \beta\left(\frac{\delta_\xi}{1+\bar{\tau}^c} + \left(\frac{\beta}{(1-\beta)\sigma} + 1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi} + \left(\frac{1}{\sigma} - 1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi}(1-\alpha) - \alpha\nu_c\right)E_t^f\tilde{\tau}_{t+1}^c \\ &+ \frac{\mu\beta}{1-\beta}((1-\alpha)E_t^F\hat{\pi}_{t+1} + \frac{\alpha d^2}{1-\beta d}\hat{\pi}_{t-1} - \frac{\alpha\beta d^2}{1-\beta d}\hat{\pi}_t) - \frac{\bar{b}}{\rho}(z_1\hat{\pi}_t + z_2\hat{\pi}_{t-1} - \alpha\beta E_t^f\hat{\pi}_{t+1}) \\ &+ (\frac{\bar{b}\beta}{\rho} - \frac{\mu\beta}{1-\beta})(z_1\hat{\tilde{i}}_t + z_2\hat{\tilde{i}}_{t-1} - \alpha\beta E_t^f\hat{\tilde{i}}_{t+1}) + \left(\left(\frac{1}{\sigma} - 1\right)\frac{1-\bar{g}}{\rho}\bar{\Pi} + \nu_c\right)z_2\tilde{\tau}_{t-1}^c,\end{aligned} \tag{116}$$

and

$$\hat{\pi}_t = c_1 E_t^F \hat{\pi}_{t+1} + \psi_t - c_1 E_t^F \psi_{t+1} + \kappa_{y1}(z_3 \hat{Y}_t + z_4 \hat{Y}_{t-1} - \alpha c_1 E_t^f \hat{Y}_{t+1}) \tag{117}$$
$$\kappa_s(z_3 \hat{s}_t + z_4 \hat{s}_{t-1} - \alpha c_1 E_t^f \hat{s}_{t+1}) + \kappa_\tau(z_3 \tilde{\tau}_t^l + z_4 \tilde{\tau}_{t-1}^l - \alpha c_1 E_t^f \tilde{\tau}_{t+1}^l)$$
$$+ \frac{c_1 \kappa_{\pi 1}}{1 - c_1}((1-\alpha) E_t^F \hat{\pi}_{t+1} + \frac{\alpha d^2}{1 - c_1 d} \hat{\pi}_{t-1} - \frac{\alpha c_1 d^2}{1 - c_1 d} \hat{\pi}_t)$$

With,

$$\psi_t = c_2 E_t^F \psi_{t+1} + \kappa_{y2}(z_5 \hat{Y}_t + z_6 \hat{Y}_{t-1} - \alpha c_2 E_t^f \hat{Y}_{t+1}) \tag{118}$$
$$+ \kappa_g(z_5 \tilde{g}_t + z_6 \tilde{g}_{t-1} - \alpha c_2 E_t^f \tilde{g}_{t+1}) + \kappa_c(z_5 \tilde{\tau}_t^c + z_6 \tilde{\tau}_{t-1}^c - \alpha c_2 E_t^f \tilde{\tau}_{t+1}^c)$$
$$+ \frac{c_2 \kappa_{\pi 2}}{1 - c_2}((1-\alpha) E_t^F \hat{\pi}_{t+1} + \frac{\alpha d^2}{1 - c_2 d} \hat{\pi}_{t-1} - \frac{\alpha c_2 d^2}{1 - c_2 d} \hat{\pi}_t) + \kappa_\xi(\hat{\xi}_t - \alpha c_2 E_t^f \hat{\xi}_{t+1}),$$

$$z_1 = 1 - \frac{\alpha \beta^2 d^2}{1 - \beta d} \tag{119}$$

$$z_2 = \frac{\alpha \beta d^2}{1 - \beta d} \tag{120}$$

$$z_3 = 1 - \frac{\alpha c_1^2 d^2}{1 - c_1 d} \tag{121}$$

$$z_4 = \frac{\alpha c_1 d^2}{1 - c_1 d} \tag{122}$$

$$z_5 = 1 - \frac{\alpha c_2^2 d^2}{1 - c_2 d} \tag{123}$$

$$z_6 = \frac{\alpha c_2 d^2}{1 - c_2 d} \tag{124}$$

D Coefficient of mean reversion in expectations of backward-looking agents.

The length of liquidity traps not only depends on how many backward-looking agents there are in the economy and on their planning horizon, but also on how persistent these

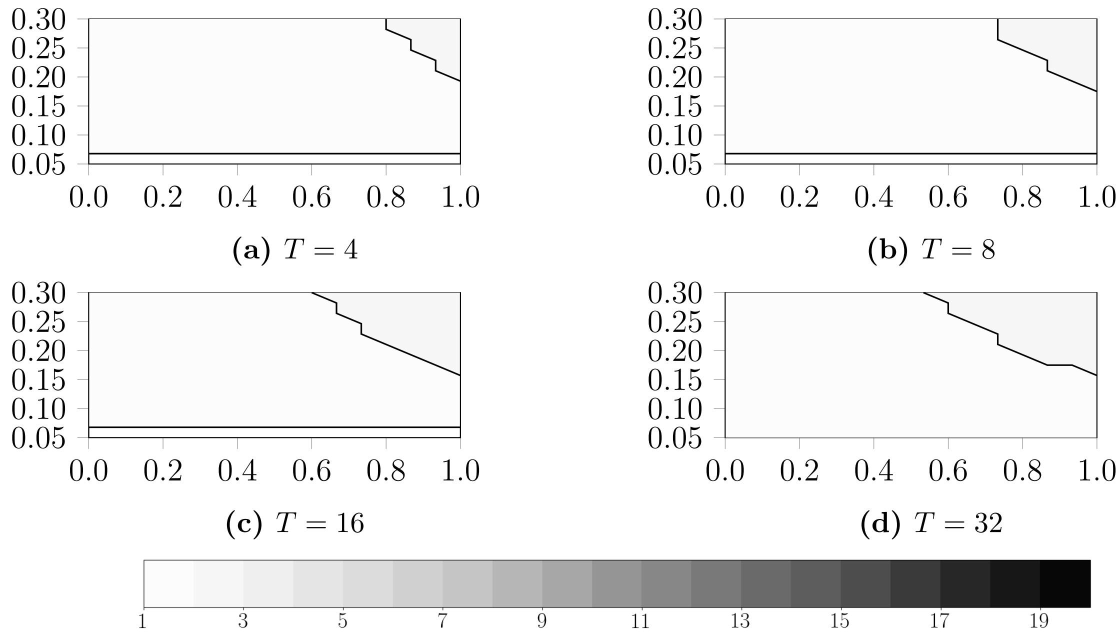


Figure 10: Length of liquidity trap in case of a lower auto-regressive coefficient in backward-looking expectations of $d = 0.5$ for different fractions of backward-looking agents (x-axis, ranging from 0 to 1) and different sizes of the (non-persistent) negative preference shock (y-axis, ranging from 0.04 to 0.3). The different panels correspond to different planning horizons. Darker color shades indicate a longer duration of the liquidity trap. The fully white areas in the bottom 4 panels indicate liquidity traps of infinite length with ever decreasing inflation and output (deflationary spirals).

agents expect variables to be. Under the benchmark calibration backward-looking agents have an auto-regressive coefficient in their expectations of 0.85. When this coefficients is reduced, the following happens in a liquidity trap. Backward-looking agents expect faster mean reversion towards the target steady state and expect the situation of low output and inflation not to last too long. This causes them to reduce consumption and prices less, so that inflation and output will indeed recover faster. This is illustrated in Figure 10, where the auto-regressive coefficient in expectations is reduced to 0.5. Liquidity traps now last at most 2 periods, even for large planning horizons. Deflationary spirals now do not arise.

When on the other hand backward-looking agents expect lower mean reversion, they reduce prices and consumption more in a liquidity trap, causing the liquidity trap to last longer, and increasing the risk of falling in a deflationary spiral. Figure 11 depicts the extreme case of an auto-regressive coefficient in expectations of 1 so that in a liquidity trap

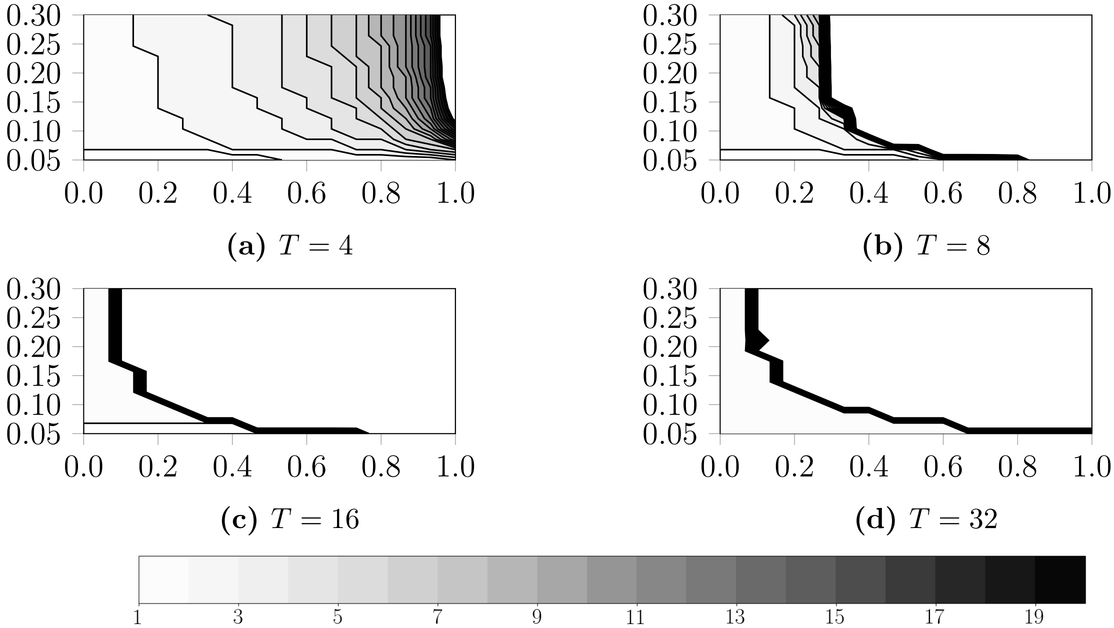


Figure 11: Length of liquidity trap in case of a lower auto-regressive coefficient in backward-looking expectations of $d = 1$ for different fractions of backward-looking agents (x-axis, ranging from 0 to 1) and different sizes of the (non-persistent) negative preference shock (y-axis, ranging from 0.04 to 0.3). The different panels correspond to different planning horizons. Darker color shades indicate a longer duration of the liquidity trap. The fully white areas in the bottom 4 panels indicate liquidity traps of infinite length with ever decreasing inflation and output (deflationary spirals).

backward-looking agents expect the liquidity trap to continue for all the periods within their planning horizon. Now deflationary spirals arise even when the fraction of backward-looking agents is not that large or when the planning horizon is small.

Note tough, that the qualitative result that large planning horizons lead to longer liquidity traps and more deflationary spirals still holds, also for different values of the auto-regressive coefficient in expectations. However, when the the auto-regressive coefficient is reduced, differences between horizons become smaller, while they become more pronounced as the the auto-regressive coefficient in expectations is increased.

105 Lena **Dräger** and Christian R. **Proaño**, Cross-Border Banking and Business Cycles in Asymmetric Currency Unions, November 2015.

106 Christian R. **Proaño** and Benjamin **Lojak**, Debt Stabilization and Macroeconomic Volatility in Monetary Unions under Heterogeneous Sovereign Risk Perceptions, November 2015.

107 Noemi **Schmitt** and Frank **Westerhoff**, Herding behavior and volatility clustering in financial markets, February 2016

108 Jutta **Viinikainen**, Guido **Heineck**, Petri **Böckerman**, Mirka **Hintsanen**, Olli **Raitakari** and Jaakko **Pehkonen**, Born Entrepreneur? Adolescents' Personality Characteristics and Self-Employment in Adulthood, March 2016

109 Stefanie P. **Herber** and Michael **Kalinowski**, Non-take-up of Student Financial Aid: A Microsimulation for Germany, April 2016

110 Silke **Anger** and Daniel D. **Schnitzlein**, Cognitive Skills, Non-Cognitive Skills, and Family Background: Evidence from Sibling Correlations, April 2016

111 Noemi **Schmitt** and Frank **Westerhoff**, Heterogeneity, spontaneous coordination and extreme events within large-scale and small-scale agent-based financial market models, June 2016

112 Benjamin **Lojak**, Sentiment-Driven Investment, Non-Linear Corporate Debt Dynamics and Co-Existing Business Cycle Regimes, July 2016

113 Julio **González-Díaz**, Florian **Herold** and Diego **Domínguez**, Strategic Sequential Voting, July 2016

114 Stefanie Yvonne **Schmitt**, Rational Allocation of Attention in Decision-Making, July 2016

115 Florian **Herold** and Christoph **Kuzmics**, The evolution of taking roles, September 2016.

116 Lisa **Planer-Friedrich** and Marco **Sahm**, Why Firms Should Care for All Consumers, September 2016.

117 Christoph **March** and Marco **Sahm**, Asymmetric Discouragement in Asymmetric Contests, September 2016.

118 Marco **Sahm**, Advance-Purchase Financing of Projects with Few Buyers, October 2016.

119 Noemi **Schmitt** and Frank **Westerhoff**, On the bimodality of the distribution of the S&P 500's distortion: empirical evidence and theoretical explanations, January 2017

120 Marco **Sahm**, Risk Aversion and Prudence in Contests, March 2017

121 Marco **Sahm**, Are Sequential Round-Robin Tournaments Discriminatory?, March 2017

122 Noemi **Schmitt**, Jan **Tuinstra** and Frank **Westerhoff**, Stability and welfare effects of profit taxes within an evolutionary market interaction model, May 2017

123 Johanna Sophie **Quis** and Simon **Reif**, Health Effects of Instruction Intensity – Evidence from a Natural Experiment in German High-Schools, May 2017

124 Lisa **Planer-Friedrich** and Marco **Sahm**, Strategic Corporate Social Responsibility, May 2017

125 Peter **Flaschel**, Matthieu **Charpe**, Giorgos **Galanis**, Christian R. **Proaño** and Roberto **Veneziani**, Macroeconomic and Stock Market Interactions with Endogenous Aggregate Sentiment Dynamics, May 2017

126 Christian **Menden** and Christian R. **Proaño**, Dissecting the Financial Cycle with Dynamic Factor Models, May 2017

127 Christoph **March** and Marco **Sahm**, Contests as Selection Mechanisms: The Impact of Risk Aversion, July 2017

128 Ivonne **Blaurock**, Noemi **Schmitt** and Frank **Westerhoff**, Market entry waves and volatility outbursts in stock markets, August 2017

129 Christoph **Laica**, Arne **Lauber** and Marco **Sahm**, Sequential Round-Robin Tournaments with Multiple Prizes, September 2017

130 Joep **Lustenhouwer** and Kostas **Mavromatis**, Fiscal Consolidations and Finite Planning Horizons, December 2017

131 Cars **Hommes** and Joep **Lustenhouwer**, Managing Unanchored, Heterogeneous Expectations and Liquidity Traps, December 2017

132 Cars **Hommes**, Joep **Lustenhouwer** and Kostas **Mavromatis**, Fiscal Consolidations and Heterogeneous Expectations, December 2017

133 Roberto **Dieci**, Noemi **Schmitt** and Frank **Westerhoff**, Interactions between stock, bond and housing markets, January 2018

134 Noemi **Schmitt**, Heterogeneous expectations and asset price dynamics, January 2018

135 Carolin **Martin** and Frank **Westerhoff**, Regulating speculative housing markets via public housing construction programs: Insights from a heterogeneous agent model, May 2018

136 Roberto **Dieci**, Noemi **Schmitt** and Frank **Westerhoff**, Steady states, stability and bifurcations in multi-asset market models, July 2018

137 Steffen **Ahrens**, Joep **Lustenhouwer** and Michele **Tettamanzi**, The Stabilizing Role of Forward Guidance: A Macro Experiment, September 2018

138 Joep **Lustenhouwer**, Fiscal Stimulus in an Expectation Driven Liquidity Trap, September 2018