Expectations, Deflation Traps, and Macroeconomic Policy

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Introduction

- Experiences of 2008 and 2009 suggest that the zero lower bound (ZLB) on interest rates may generate a "liquidity trap". The economy then has the potential of getting stuck in a deflationary situation with low levels of output.

- Various papers (Krugman 1998, Eggertsson and Woodford 2003 etc.) have examined liquidity traps using an RE perspective.

- The learning view (Evans and Honkapohja 2005, Evans, Guse and Honkapohja 2008) emphasizes the role of evolution of expectations in the dynamics of temporary equilibria.

- Evans, Guse and Honkapohja (2008) analyzed global dynamics in a standard NK model under the assumption that agents' decision rules had a short horizon, i.e. were based on Euler equations. But commitment to low interest rates cannot be studied.

- This paper replaces "Euler-equation learning" with the assumption that agents have infinite-horizon decision rules (as suggested by Marcet and Sargent 1989 and Preston 2005, 2006 among others).

- We study aspects of global learning dynamics and policies to avoid deflation traps in a standard NK model with household-firms producing differentiated goods under monopolistic competition and price-adjustment costs.

The Model

- Normal monetary policy is specified by a rule in which interest rate depends on expected inflation.

- Government buys some output, financed by lump-sum taxes and debt.

- We assume that consumers are fully Ricardian. $=>$ Consumption function depends on expected future interest rates and incomes net of government spending.

- Agent s solves

$$Max\ E_0 \sum_{t=0}^{\infty} \beta^t U_{t,s} \left(c_{t,s}, \frac{M_{t-1,s}}{P_t}, h_{t,s}, \frac{P_{t,s}}{P_{t-1,s}} - 1 \right) \quad (1)$$

$$st.\ c_{t,s} + m_{t,s} + b_{t,s} + \Upsilon_{t,s} = m_{t-1,s}\pi_t^{-1} + R_{t-1}\pi_t^{-1} b_{t-1,s} + \frac{P_{t,s}}{P_t} y_{t,s}, \quad (2)$$

where $c_{t,s}$ is the consumption aggregator, $M_{t,s}$ and $m_{t,s}$ are nominal and real money balances, $h_{t,s}$ is the labor input, $b_{t,s}$ is the real quantity of risk-free one-period nominal bonds, $\Upsilon_{t,s}$ is the lump-sum tax, R_{t-1} is the nominal interest rate factor between $t-1$ and t, $P_{t,s}$ is the price of good s, $y_{t,s}$ is output of good s, P_t is the level, and the inflation rate is $\pi_t = P_t/P_{t-1}$.

- The utility function has the parametric form

$$U_{t,s} = \frac{c_{t,s}^{1-\sigma_1}}{1-\sigma_1} + \frac{\chi}{1-\sigma_2}\left(\frac{M_{t-1,s}}{P_t}\right)^{1-\sigma_2} - \frac{h_{t,s}^{1+\varepsilon}}{1+\varepsilon} - \frac{\gamma}{2}\left(\frac{P_{t,s}}{P_{t-1,s}} - 1\right)^2.$$

The final term is the cost of adjusting prices. There is also the "no Ponzi game" condition.

- Production function for good s is

$$y_{t,s} = h_{t,s}^{\alpha}$$

where $0 < \alpha < 1$. Each firm faces a demand curve

$$P_{t,s} = \left(\frac{y_{t,s}}{Y_t}\right)^{-1/\nu} P_t. \tag{3}$$

$P_{t,s}$ is the profit maximizing price. Y_t is aggregate output.

- The government's flow budget constraint is

$$b_t + m_t + \Upsilon_t = g_t + m_{t-1}\pi_t^{-1} + R_{t-1}\pi_t^{-1}b_{t-1}, \tag{4}$$

where g_t is government consumption, b_t is the real quantity of government debt, and Υ_t is the real lump-sum tax. Fiscal policy follows a linear tax rule

$$\Upsilon_t = \kappa_0 + \kappa b_{t-1} + \eta_t, \tag{5}$$

where η_t is a white noise shock and where $\beta^{-1} - 1 < \kappa < 1$, i.e. fiscal policy is "passive" (Leeper 1991).

- g_t is stochastic $g_t = \bar{g} + u_t$,where u_t is a stationary AR(1) mean zero shock. From market clearing we have

$$c_t + g_t = y_t. \tag{6}$$

- Monetary policy is assumed to follow a global interest rate rule

$$R_t - 1 = \theta_t f\left(\pi_{t+1}^e\right). \tag{7}$$

$f(\pi)$ is positive and non-decreasing. π_{t+1}^e is expected inflation. θ_t is an observable stationary AR(1) positive random shock with mean 1. There exist a targeted steady state $\pi^* \geq 1$ and R^* such that $R^* = \beta^{-1}\pi^*$ and $f(\pi^*) = R^* - 1$.

- The preceding constitutes "normal policy".

- We assume identical expectations and simplify by focusing on "steady-state" learning (no random shocks), assume log utility and point expectations.

The infinite-horizon Phillips curve

- Let $Q_t = (\pi_t - 1)\,\pi_t$, with the appropriate root $\pi \geq \frac{1}{2}$. We can obtain

$$Q_t = \frac{\nu}{\gamma} \sum_{j=0}^{\infty} \alpha^{-1} \beta^j \left(y^e_{t+j}\right)^{(1+\varepsilon)/\alpha} - \frac{\nu - 1}{\gamma} \sum_{j=0}^{\infty} \beta^j \left(\frac{y^e_{t+j}}{x^e_{t+j}}\right). \qquad (8)$$

  Here x^e_{t+j} denotes expected net output, which equals expectations of $y_{t+j} - g_{t+j}$. Expectations are formed at t and variables at time t are in the information set of the agents.

- These are temporary equilibrium equations that determine π_t given expectations $\{y^e_{t+j}, x^e_{t+j}\}_{j=1}^{\infty}$.

The consumption function

- The life-time budget constraint of the household is

$$
\begin{aligned}
0 &= r_t b_{t-1} + \Phi_t + \sum_{j=1}^{\infty} (D^e_{t,t+j})^{-1} \Phi^e_{t+j}, \text{ where} \\
D^e_{t,t+j} &= \prod_{i=1}^{j} r^e_{t+i}, \ \text{ where } r^e_{t+i} = (1 + f(\pi^e_{t+i}))/\pi^e_{t+i} \text{ and} \\
\Phi^e_{t+j} &= y^e_{t+j} + m^e_{t+j-1}(\pi^e_{t+j})^{-1} - c^e_{t+j} - m^e_{t+j} - \Upsilon^e_{t+j}.
\end{aligned}
$$

- Tax forecasts: households understand the government's intertemporal budget constraint. These lead to the consumption function

$$
c_t = (1-\beta)\left(y_t - g_t + \sum_{j=1}^{\infty} (D^e_{t,t+j})^{-1} x^e_{t+j} \right). \tag{9}
$$

Proposition 1 *Household consumption depends on the sequence of expected government spending but not in any way on how it is financed.*

Learning and Stability

- Assume that $g_t = \bar{g}$ and agent know this and set $x^e_{t+j} = y^e_{t+j} - \bar{g}$. For any steady state π, the Fisher equation holds

$$R = \beta^{-1}\pi. \tag{10}$$

ZLB implies that there are two steady states: (i) π^* with $f'(\pi^*) > \beta^{-1}$ and (ii) $\pi_L < \pi^*$ with $f'(\pi_L) < \beta^{-1}$. π^* is locally determinate and π_L is locally indeterminate.

- **Temporary equilibrium**: six model equations yield values for c_t, π_t, y_t, R_t, m_t, b_t, given expectations $\{y^e_{t+j}, \pi^e_{t+j}\}_{j=1}^{\infty}$.

- Evolution of expectations:
  - private agents make forecasts using a reduced form econometric model of the relevant variables
  - the parameters of this model are estimated using past data.
  - forecasts are input to agent's decision rules and in each period a temporary equilibrium obtains, given the forecasts.

- Dynamics: temporary equilibrium yields a new data point, parameters are re-estimated, and forecasts updated $=>$ new temporary equilibrium.

- If parameter estimates converge to a fixed point corresponding to REE for the economy, we say that the **REE is stable under learning**.

- Steady state learning with point expectations:

$$y^e_{t+j} = y^e_t \text{ and } \pi^e_{t+j} = \pi^e_t \text{ for all } j \geq 1.$$

and that

$$z^e_t = z^e_{t-1} + \omega_t(z_{t-1} - z^e_{t-1}) \tag{11}$$

for $z = y, \pi$. Here $\omega_t = t^{-1}$ under "decreasing gain" learning for $\omega_t = \omega$, for $0 < \omega \leq 1$ for "constant gain" learning.

- There is close connection between convergence of least squares learning to an REE and E-stability of the REE.

- Analysis: temporary equilibrium equations for output and inflation are

$$y_t = \bar{g} + (\beta^{-1} - 1)(y_t^e - \bar{g}) \left(\frac{\pi_t^e}{1 + f(\pi_t^e) - \pi_t^e} \right) \equiv G_1(y_t^e, \pi_t^e).$$

$$\begin{aligned}
\pi_t &= Q^{-1}[K(G_1(y_t^e, \pi_t^e), y_t^e)] \equiv G_2(y_t^e, \pi_t^e), \text{ where} \\
Q(\pi_t) &\equiv (\pi_t - 1)\,\pi_t \\
K(y_t, y_t^e) &\equiv \frac{\nu}{\gamma}\left(\alpha^{-1} y_t^{(1+\varepsilon)/\alpha} - \left(1 - \nu^{-1}\right)\frac{y_t}{(y_t - \bar{g})}\right) \\
&\quad + \frac{\nu}{\gamma}\left(\beta(1-\beta)^{-1}\left(\alpha^{-1}(y_t^e)^{(1+\varepsilon)/\alpha} - \left(1 - \nu^{-1}\right)\frac{y_t^e}{(y_t^e - \bar{g})}\right)\right).
\end{aligned}$$

- The E-stability equations are

$$\frac{dy^e}{d\tau} = G_1(y^e, \pi^e) - y^e \tag{12}$$
$$\frac{d\pi^e}{d\tau} = G_2(y^e, \pi^e) - \pi^e.$$

  An **REE is E-stable** if it is locally asymptotically stable under (12). We have:

Proposition 2 *The model with normal policy has two steady state states* π^* *and* π_L. *Under infinite-horizon decision rules with steady-state learning the targeted steady state* π^* *is locally stable under learning. For* γ *sufficiently small the low-inflation steady state is locally unstable taking the form of a saddle point.*

- Global results by numerical analysis.

  - Truncate the steady state expectations at some long but finite horizon T and assume that at T real rate of interest has reached its steady state value β^{-1}.

  - Make sure that $\pi \geq 1/2$.

  - The parameter values are $A = 2.5$, $\pi^* = 1.02$, $\beta = 0.99$, $\alpha = 0.75$, $\beta = 20$, $\nu = 1.5$, $\varepsilon = 1$, $R^* = \pi^*/\beta$, $\bar{g} = 0.1$ and $T = 50$.

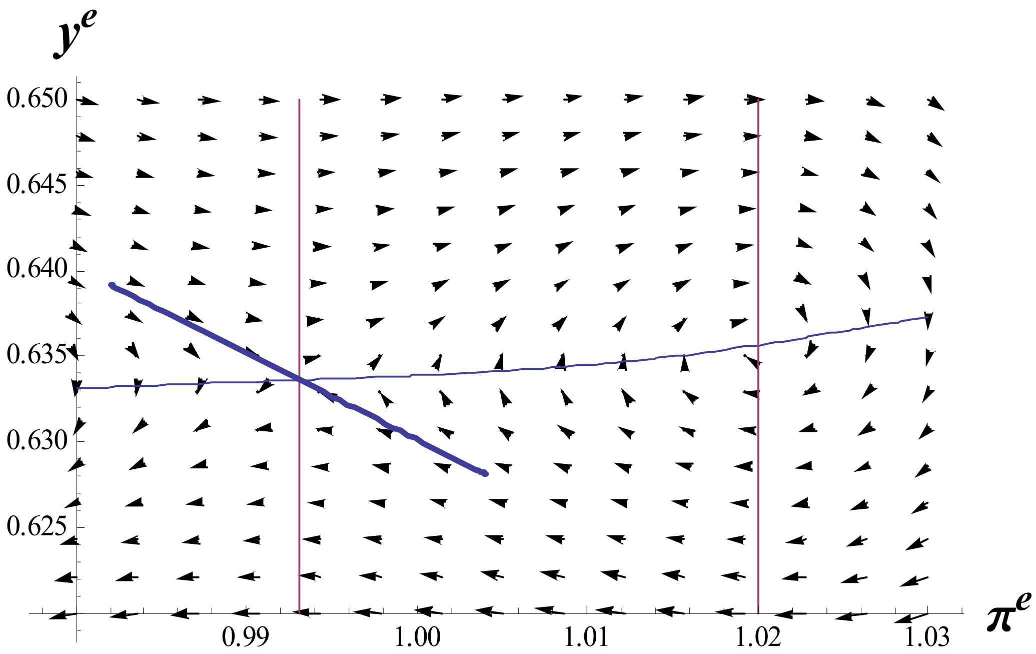

Figure 1: E-stability dynamics under global Taylor rule

- The low steady state is a saddle point and there is a region of **deflationary spirals**.

Alternative Monetary and Fiscal Policies

Committing to Low Interest Rates

- Aggressive monetary easing triggered by inflation rates below some threshold $\tilde{\pi}$. where $\pi_L < \tilde{\pi} < \pi^*$ is not a fool-proof way to avoid deflationary spirals (Evans, Guse and Honkapohja 2008). Longer-term commitment could not be studied.

- In models with RE commitment to long periods of low interest rates has been advocated as a way to avoid the consequences of liquidity traps (Krugman 1998, Eggertsson and Woodford 2003, Svensson 2003).

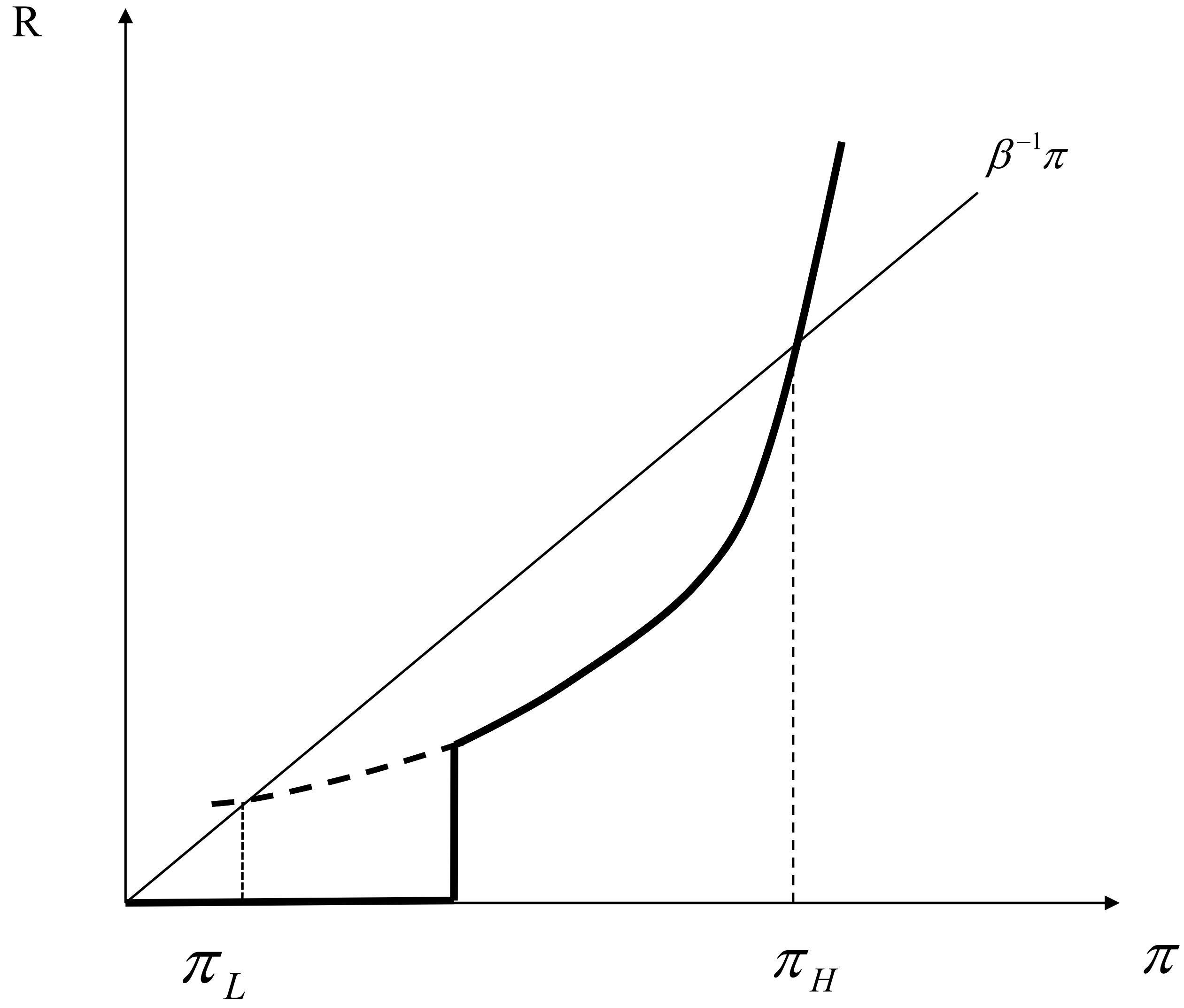

Figure 2: Aggressive monetary easing

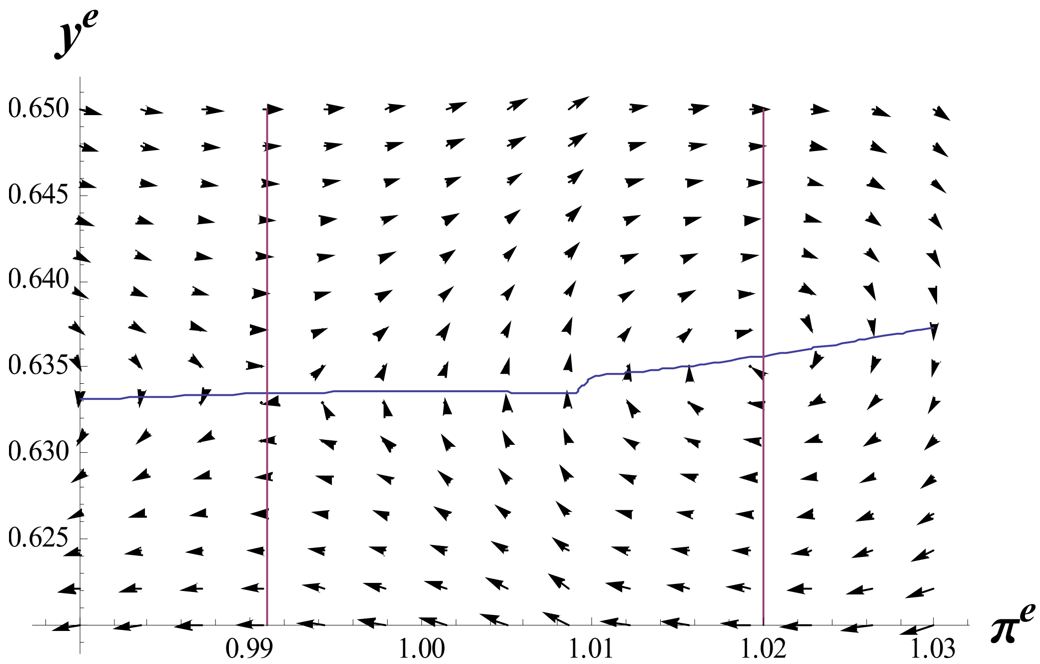

Figure 3: Global expectations dynamics with aggressive monetary easing

- Some help (lower π_L), but not fool-proof.

- Problem remains even if policy makers respond to low inflation by committing to the low interest rate policy forever.

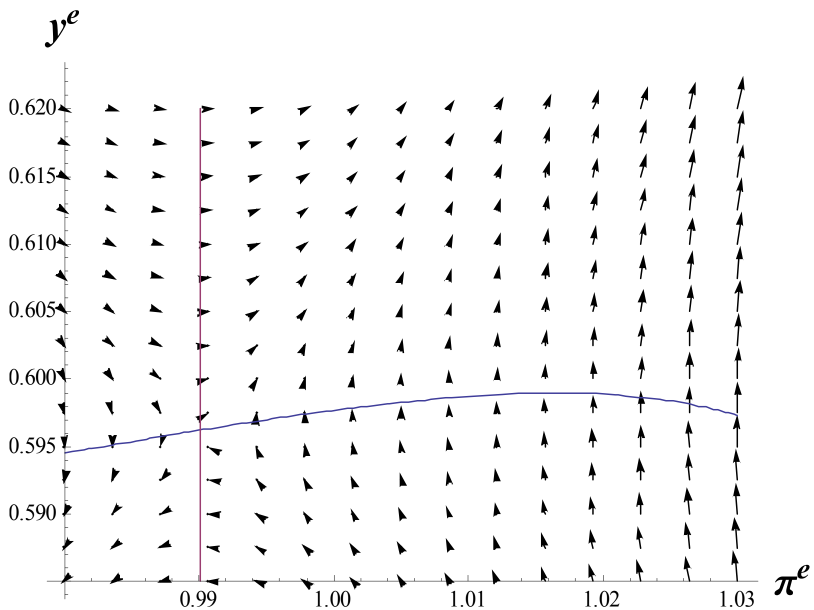

Figure 4: Dynamics with aggressive monetary easing forever

Combined Monetary and Fiscal Easing

- Add aggressive fiscal policy following the ideas of Evans, Guse and Honkapohja (2008).
  - Fiscal easing: if we would have $\pi_t < \tilde{\pi}_1$ at $g_t = \bar{g}$ then g_t is increased to ensure $\pi_t = \tilde{\pi}_1$:

Lemma 3 *For given expectations* π_t^e*,* y_t^e*,* x_t^e*,*

$$\frac{d\pi_t}{dg_t} \geq k$$

for some $k > 0$ *and* g_t *sufficiently large.*

Proposition 4 *Consider the temporary equilibrium system with fiscal easing triggered by the threshold* $\tilde{\pi}_1$*. There is a unique steady state with inflation at* π^* *and a corresponding value for output. At the steady state* $g_t = \bar{g}$*.*

- Numerical results indicate that the steady state is globally stable under learning.
  - Pick a starting point $\pi^e = 0.995$, $y^e = 0.62$ and $x^e = 0.52$ from the deflationary region.

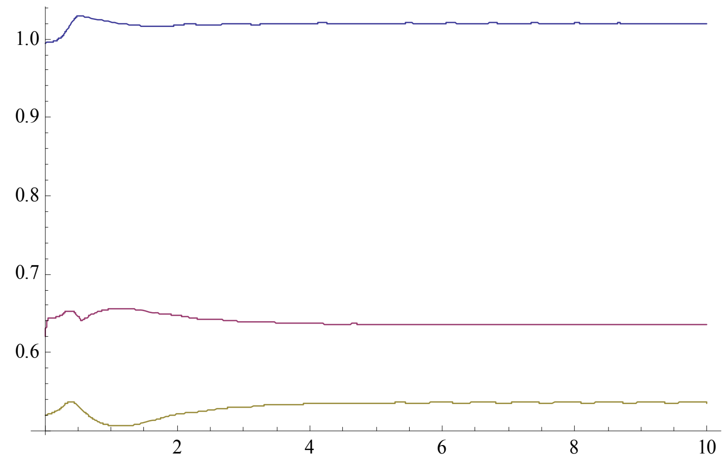

Figure 5: Inflation, output, and net output expectations over time

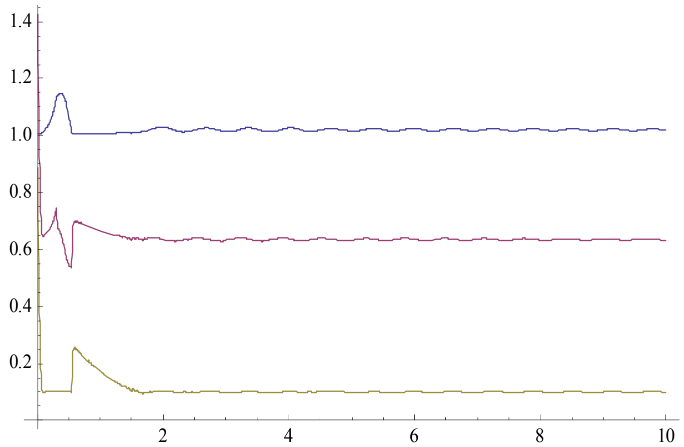

Figure 6: Time paths of actual inflation, ouput, and net output

- By stabilizing prices through expansionary government spending, low nominal interest rates yield low expected real interest rates. This leads to a recovery of private spending.

Conclusions

- Remaining issue: the resulting path is cyclical and exhibits overshooting of the inflation target after the economy is pushed out of the deflationary region.

- Are there more refined rules to avoid these fluctuations?

- Would an output threshold work (not according to Evans, Guse and Honkapohja 2008)?