Expectations, Stagnation and Fiscal Policy

by

George W. Evans, University of Oregon and U of St. Andrews

Seppo Honkapohja, Bank of Finland

Kaushik Mitra, University of Birmingham

Keynote lecture in Amsterdam, September 8, 2016

1. Introduction

- The sluggish macro performance of any economies in the aftermath of the Great Recession has raised interest in the possibility of a distinct stagnation state associated with the interest-rate zero lower bound (ZLB).

- We develop an extension of the New Keynesian (NK) model that allows existence of a stagnation steady state (trap).
  – This is a lack of confidence story of stagnation.
  – Pricing friction in the NK model provides a role for expectations to affect GDP via aggregate demand.
  – We assume agents make forecasts using adaptive learning (AL) instead of rational expectations (RE).

- Using AL allows us to check whether the different RE steady states are locally stable under learning.
  – We show that both the targeted steady state and the stagnation steady state are locally stable under learning.
  – A third "middle" steady state often discussed is not locally stable.

- We then look at fiscal policy:
  – a large temporary stimulus can be effective in avoiding stagnation.
  – government spending multipliers are large at the ZLB. If the economy would otherwise go to the stagnation trap multipliers are huge.

- However, in the stagnation trap, there are nonlinearities:
  – a very large fiscal stimulus is sometimes needed to push the economy back to the normal (targeted) steady state.
  – The success rate for a fiscal stimulus is higher if done earlier.

Background on ZLB in NK models

- Eggertsson and Woodford (2003), Christiano et al. (2011), Woodford (2011) have emphasized that exogenous discount rate shocks or credit-spread shocks can push the economy into a recession at the ZLB.
  – An unattractive feature: it does not do justice to the possibility of self-reinforcing pessimistic expectations that outlive the exogenous shocks.

- Benhabib, Schmidt-Grohe and Uribe (2001a,b) focus on the existence of multiple REE when the interest rate is subject to the ZLB: there are two intersections of the Fisher equation and the interest-rate rule.
  – Bullard (2010) has illustrated this using data on inflation and interest rates. See our updated Figure.

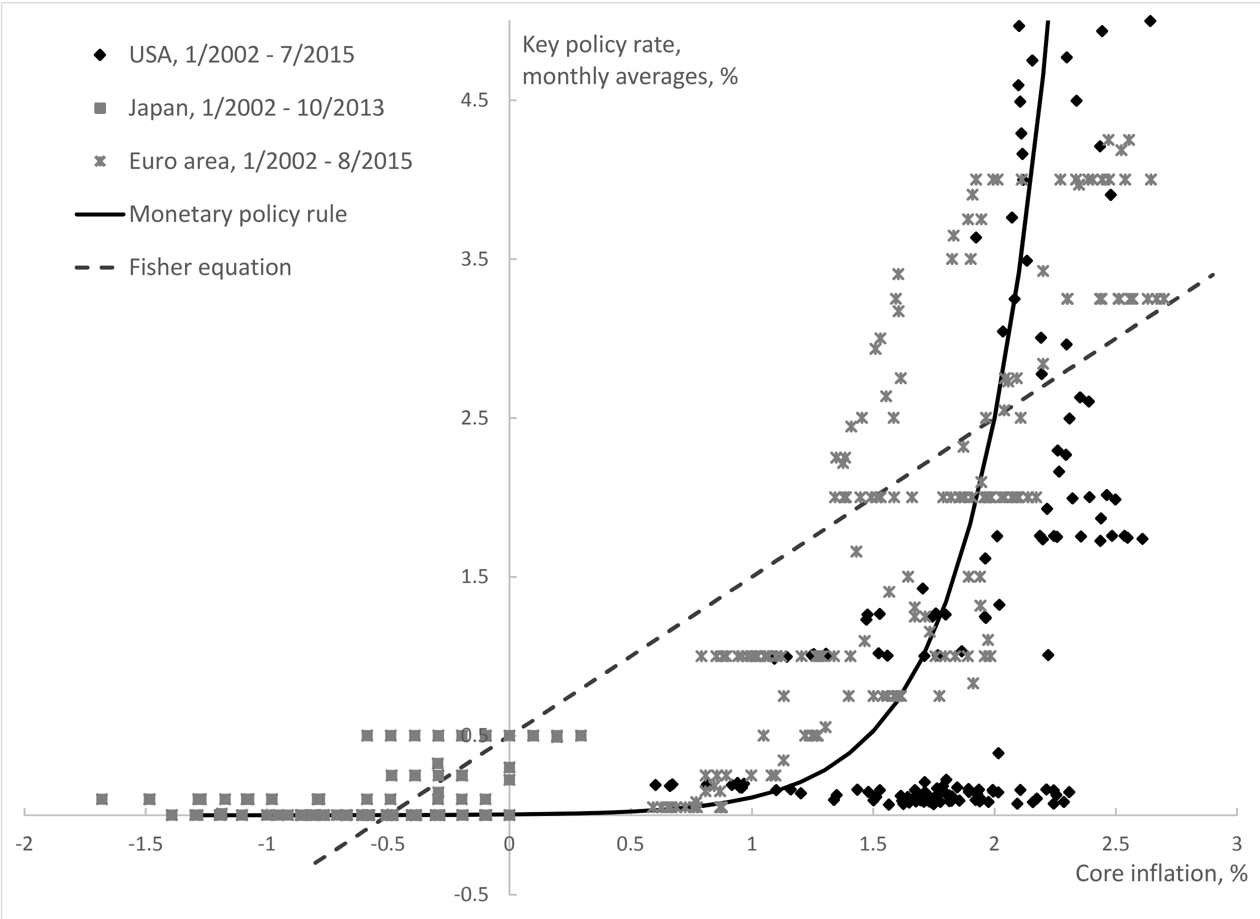

Figure 1: Interest rate vs inflation in Japan, US and euro area

- One problem with the BS-GU approach is that steady state output in the targeted and the low inflation steady state is almost the same. But the concern about the ZLB & deflation is its association with severe recession and stagnation. See figures for GDP per capita.

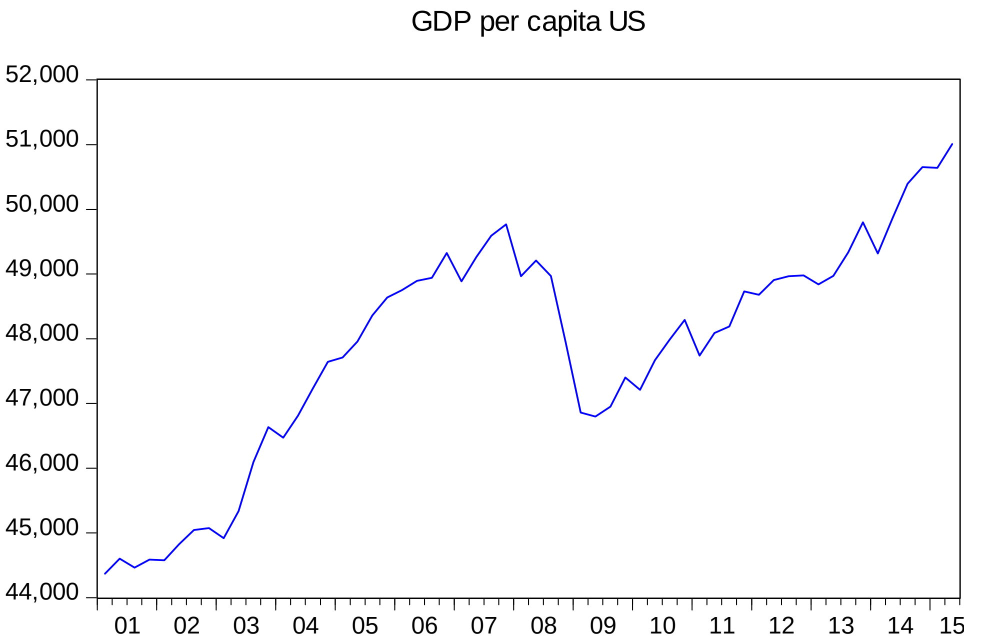

Figure 2a: US real GDP per capita in dollars

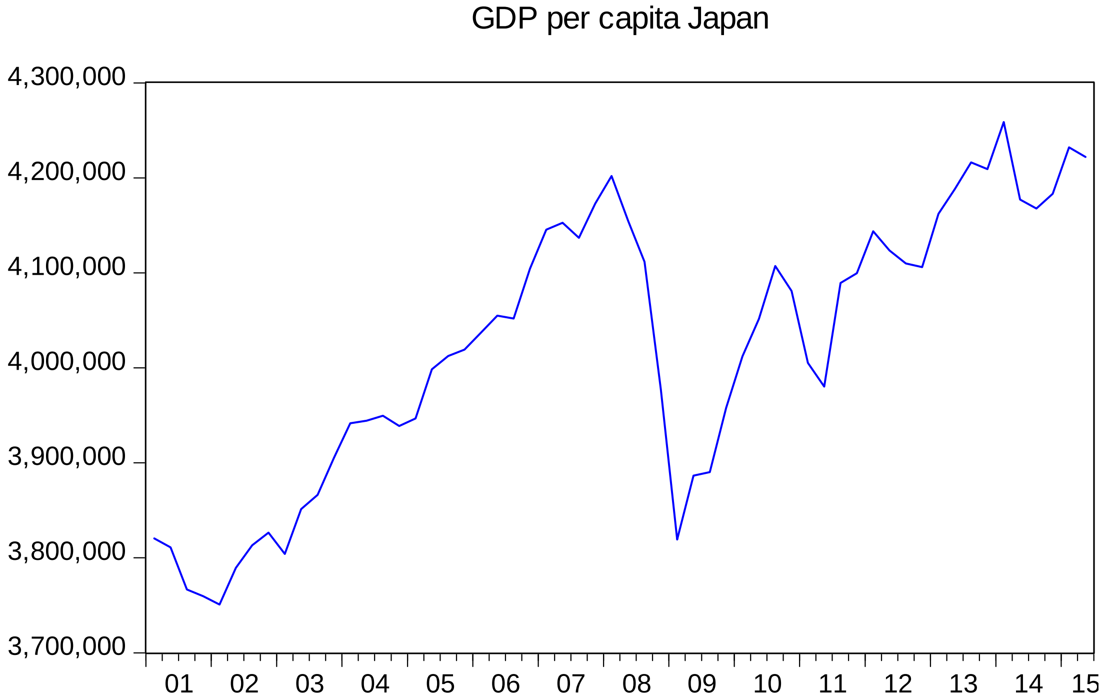

Figure 2b: Japan real GDP per capita in yen

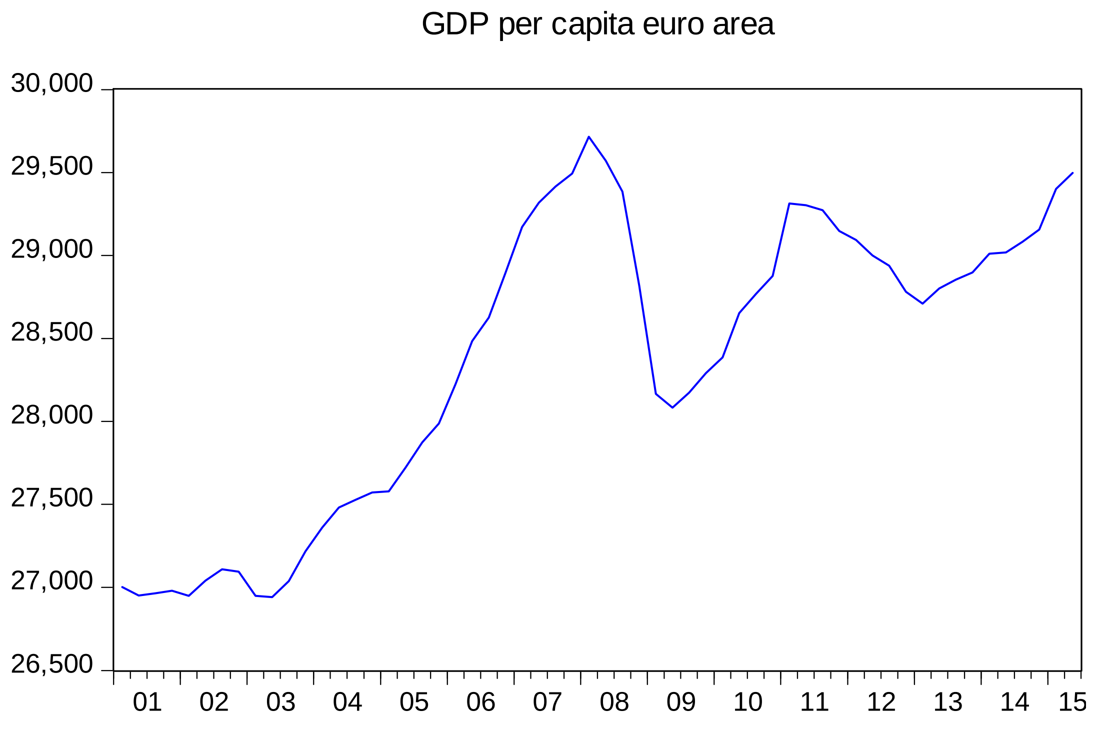

Figure 2c: Euro area real GDP per capita in euros

- A second problem: the unintended low inflation/deflation steady state is not locally stable under learning. See Evans, Guse and Honkapohja (2008) and Benhabib, Evans and Honkapohja (2014).
  – The intended steady state is locally stable under learning, but EGH & BEH also emphasize the possibility under AL of a deflation trap with falling output over time.

- Central intuition of deflation trap: zero interest rate + expected deflation $\longrightarrow$ high real interest rate $\longrightarrow$ lower consumption, output and greater deflation.

- Another approach, e.g. Mertens and Ravn (2014), relies on a sunspot solution based on the two steady states. This also has the two objections: (i) recessions associated with ZLB are small, and (ii) instability under AL.

Our Approach

- The Great Recession was large and long in the US and in Japan. Low levels of output persist in several countries of the euro area. In the US Great Depression deflation and the ZLB were accompanied by over a 25% drop in GDP.

- In the current paper we modify the model to create a third stagnation (deep recession) steady state by adding **lower bounds** to inflation and consumption.

- A lower bound to inflation is motivated by empirical experience at low output levels.

- A stagnation steady state exists if the inflation rate lower bound is below a deflation rate equal to the discount rate. It is locally stable under learning.

- Suppose the economy is subject to exogenous credit-spread shocks. These may leave agents with pessimistic expectations after the shocks have ceased. Under AL there is then the possibility of converging to stagnation.

- We show that a short-term government spending stimulus can be effective: it increases aggregate demand, which raises output and inflation. Under AL this may increase expected future inflation and output enough to pull the economy back to the targeted steady state.

2. NK Model Without Lower Bounds

We start with a standard NK model and use Eusepi and Preston (AEJmacro, 2010) to get decision rules under adaptive learning (AL).

We use the Rotemberg pricing friction. Households are indexed by i and firms by j but in equilibrium agents make the same respective decisions.

Households

Household i chooses $C_{t,i}, h_{t,i}, b_{t,i}$ to solve

$$Max\ \hat{E}_{0,i} \sum_{t=0}^{\infty} \beta^t \left(\log C_{t,i} - \gamma \frac{h_{t,i}^{1+\varepsilon}}{1+\varepsilon} \right)$$

$$\text{s.t. } C_{t,i} + b_{t,i} + \Upsilon_{t,i} = R_{t-1}\pi_t^{-1} b_{t-1,i} + Y_{t,i} \text{ and } Y_{t,i} = \frac{W_t}{P_t} h_{t,i} + \Omega_t^i$$

We assume **Ricardian households**. The usual FOCs are

$$C_{t,i}^{-1} = \beta R_t \hat{E}_{t,i}\left(\pi_{t+1}^{-1} C_{t+1,i}^{-1}\right) \text{ and } W_t/P_t = \gamma h_{t,i}^{\varepsilon} C_{t,i}.$$

In the RE approach it is standard to use equations linearized around steady state values. Eusepi & Preston extend this approach to an AL setting.

Government spending is exogenous and financed by lump-sum taxes. Linearizing the IBC and the Euler equation gives the consumption function

$$\begin{aligned}\hat{C}_{t,i} \;&=\; (1-\beta)\left[\frac{\hat{Y}_{t,i}}{\left(\bar{C}/\bar{Y}\right)} - \frac{\hat{G}_{t,i}}{\left(\bar{C}/\bar{G}\right)} + \sum_{s=1}^{\infty} \beta^s \hat{E}_{t,i}\left(\frac{\hat{Y}_{t+s,i}}{\left(\bar{C}/\bar{Y}\right)} - \frac{\hat{G}_{t+s,i}}{\left(\bar{C}/\bar{G}\right)})\right)\right] \\ &\quad -\hat{E}_{t,i}\sum_{s=1}^{\infty}\beta^s \hat{r}_{t+s},\end{aligned}$$

where variables are in proportional deviation form and $\hat{r}_{t+1} = \hat{R}_t - \hat{\pi}_{t+1}$.

Firms

Standard NK set-up with monopolistic competition and Rotemberg pricing friction. Firm j production function and inverse demand curve are

$$Y_{t,j} = A_t h_{t,j}^{\alpha} \text{ and } P_{t,j} = \left(\frac{Y_{t,j}}{Y_t}\right)^{-1/\theta_t} P_t$$

The firms' problem is

$$Max\ \hat{E}_{T,j} \sum_{T=t}^{\infty} Q_{t,T} P_T \Omega_{T,j} \text{ where } Q_{t,T} = \beta^{T-t} \frac{P_t C_t}{P_T C_T}, \text{ for } T \geq t \text{ and}$$

$$\Omega_{t,j} = (1-\tau)\frac{P_{t,j}}{P_t} Y_{t,j} - \frac{W_t}{P_t} h_{t,j} - \frac{\psi}{2}\left(\frac{P_{t,j}}{P_{t-1,j}} - \pi^*\right)^2,$$

Here $\psi > 0$ indexes the pricing friction and π^* is the policy inflation target.

The dynamic FOC is

$$\begin{aligned} 0 &= (1-\tau)(1-\theta_t)\left(\frac{P_{t,j}}{P_t}\right)^{-\theta_t} Y_t + S_t Y_t \theta_t \left(\frac{P_{t,j}}{P_t}\right)^{-\theta_t - 1} \\ &\quad -\psi \frac{P_{t,j}}{P_{t-1,j}}\left(\frac{P_{t,j}}{P_{t-1,j}} - \pi^*\right) + \hat{E}_{t,j} Q_{t,t+1} \frac{P_{t+1}}{P_{t,j}} \psi \frac{P_{t+1,j}}{P_{t,j}} \left(\frac{P_{t+1,j}}{P_{t,j}} - \pi^*\right). \end{aligned}$$

where $S_{t,j} = (W_t/P_t)/(\partial Y_{t,j}/\partial h_{t,j})$ is real MC. Linearizing gives the PC

$$\begin{aligned} (1-a_1)\hat{\pi}_t - a_2 \hat{Y}_t &= a_1 \sum_{s=1}^{\infty} (\beta\gamma_1)^s \hat{E}_t \hat{\pi}_{t+s} + a_2 \sum_{s=1}^{\infty} (\beta\gamma_1)^s \hat{E}_t \hat{Y}_{t+s} \\ &\quad - a_3 \sum_{s=0}^{\infty} (\beta\gamma_1)^s \hat{E}_t \hat{A}_{t+s} - a_4 \sum_{s=0}^{\infty} (\beta\gamma_1)^s \hat{E}_t \hat{G}_{t+s} \\ &\quad + a_5 \sum_{s=0}^{\infty} (\beta\gamma_1)^s \hat{E}_t \hat{\mu}_{t+s}, \text{ where } 0 < \gamma_1 < 1, \end{aligned}$$

and $a_1 = 1 - \gamma_1$. Here $\mu_t = \theta_t (\theta_t - 1)^{-1}$ is the mark-up shock.

Temporary equilibrium and learning

The consumption function and the PC provide the consumption and price setting decisions with given expectations.

The market clearing equation is

$$Y_t = C_t + G_t + (\psi/2)(\pi_t - \pi^*)^2.$$

In the steady state at $\pi = \pi^*$ we have $\bar{Y} = \bar{C} + \bar{G}$ or $\hat{Y}_t = (1-\bar{g})\hat{C}_t + \bar{g}\hat{G}_t$ where $\bar{g} = \bar{G}/\bar{Y}$. Combining with the consumption function gives **the IS-curve**

$$\begin{aligned}\hat{Y}_t &= \bar{g}\hat{G}_t + (1-\beta)\left[\hat{Y}_t - \bar{g}\hat{G}_t + \sum_{s=1}^{\infty}\beta^s \hat{E}_t\left(\hat{Y}_{t+s} - \bar{g}\hat{G}_{t+s}\right)\right] \\ &\quad -(1-\bar{g})\hat{E}_t\sum_{s=1}^{\infty}\beta^s \hat{r}_{t+s},\end{aligned}$$

The interest-rate rule is

$$R_t = \beta^{-1}\left(\pi^* + \chi_\pi(\pi_t - \pi^*) + \chi_y(Y_t - \bar{Y})\right).$$

In log-linearized form, and assuming $\chi_y = 0$,

$$\hat{R}_t = \chi_\pi \hat{\pi}_t.$$

Agents are assumed to know the rule, so to forecast $\hat{r}_{t+s} = \hat{R}_{t+s} - \hat{\pi}_{t+s+1}$ and $\hat{R}_{t+s}$ they need to forecast $\hat{\pi}_{t+s}$ and $\hat{Y}_{t+s}$. For simplicity we assume agents know the form of the exogenous productivity and mark-up shocks.

$$\begin{aligned} \hat{A}_t &= \rho_A \hat{A}_{t-1} + \upsilon_{At}, \\ \hat{\mu}_t &= \rho_\mu \hat{\mu}_{t-1} + \upsilon_{\mu t}, \end{aligned}$$

Given agents' forecasts $\hat{E}_t\hat{\pi}_{t+s}, \hat{E}_t\hat{Y}_{t+s}, \hat{E}_t\hat{G}_{t+s}, \hat{E}_t\hat{A}_{t+s}, \hat{E}_t\hat{\mu}_{t+s}$ and the shocks $\hat{G}_t, \hat{A}_t, \hat{\mu}_t$ we can solve for **temporary equilibrium** $\hat{Y}_t, \hat{\pi}_t, \hat{R}_t$, $\hat{C}_t$.

Expectations and learning

To complete our dynamic system we describe how expectations are updated. When $G_t = \bar{G}$ is constant, the REE around π^* takes the form

$$\hat{\pi}_t = f_\pi + d_{\pi A}\hat{A}_t + d_{\pi\mu}\hat{\mu}_t \text{ and } \hat{Y}_t = f_Y + d_{YA}\hat{A}_t + d_{Y\mu}\hat{\mu}_t.$$

Including f_π, f_Y allows agents to track changes in π and Y.

Under **least-squares** (LS) learning the coefficients are estimated using the data and updated over time. Given time t estimates agents compute

$$\hat{E}_t\hat{\pi}_{t+s} = f_\pi + d_{\pi A}\rho_A^s\hat{A}_t + d_{\pi\mu}\rho_\mu^s\hat{\mu}_t \text{ and } \hat{E}_t\hat{Y}_{t+s} = f_Y + d_{YA}\rho_A^s\hat{A}_t + d_{Y\mu}\rho_\mu^s\hat{\mu}_t$$

and make decisions accordingly.

To forecast inflation and output, agents use LS learning, as described above. Formally if parameter estimates based on data through time t are

$$\phi_{\pi,t} = \begin{pmatrix} f_{\pi,t} \\ d_{\pi A,t} \\ d_{\pi\mu,t} \end{pmatrix}, \phi_{y,t} = \begin{pmatrix} f_{y,t} \\ d_{yA,t} \\ d_{y\mu,t} \end{pmatrix}, z_t = \begin{pmatrix} 1 \\ \hat{A}_t \\ \hat{\mu}_t \end{pmatrix},$$

then

$$\begin{aligned} \phi_{\pi,t} &= \phi_{\pi,t-1} + \kappa \mathcal{R}_t^{-1} z_t(\pi_t - \phi_{\pi,t-1} z_t), \\ \phi_{y,t} &= \phi_{y,t-1} + \kappa \mathcal{R}_t^{-1} z_t(y_t - \phi_{y,t-1} z_t), \\ \mathcal{R}_t &= \mathcal{R}_{t-1} + \kappa(z_t z_t' - \mathcal{R}_{t-1}). \end{aligned}$$

Under strict LS learning κ is replaced by t^{-1}. We instead use a constant "gain" parameter $0 < \kappa < 1$, which is better at tracking structural changes, like the unknown effects on Y and π of the policy.

The REE at π^* is stable under LS learning: if $G_t = \bar{G}$ is constant estimates converge over time to RE values.

3. Model with Multiple Equilibria

We now allow for lower bounds to R, C and π. We start with R.

- For the interest rate ZLB $R \geq 1$ i.e. $R - 1 \geq 0$, we write the lower bound, for $\eta \geq 0$ small, as

$$R_t = \max\left\{(\chi_\pi/\beta)(\pi_t - \pi^*) + \pi^*/\beta, 1 + \eta\right\}, \text{ where } \chi_\pi > 1.$$

- The consumption Euler equation is

$$C_t^{-1} = \beta R_t \hat{E}_t \left(\pi_{t+1}^{-1} C_{t+1}^{-1}\right)$$

  In a steady state this gives the Fisher equation

$$R = r\pi, \text{ where } r = \beta^{-1}.$$

- Putting together Fisher and the i rule gives two steady states at π_L and π^*. From the PC $Y_L < \bar{Y}$ but numerically $Y_L \approx \bar{Y}$.

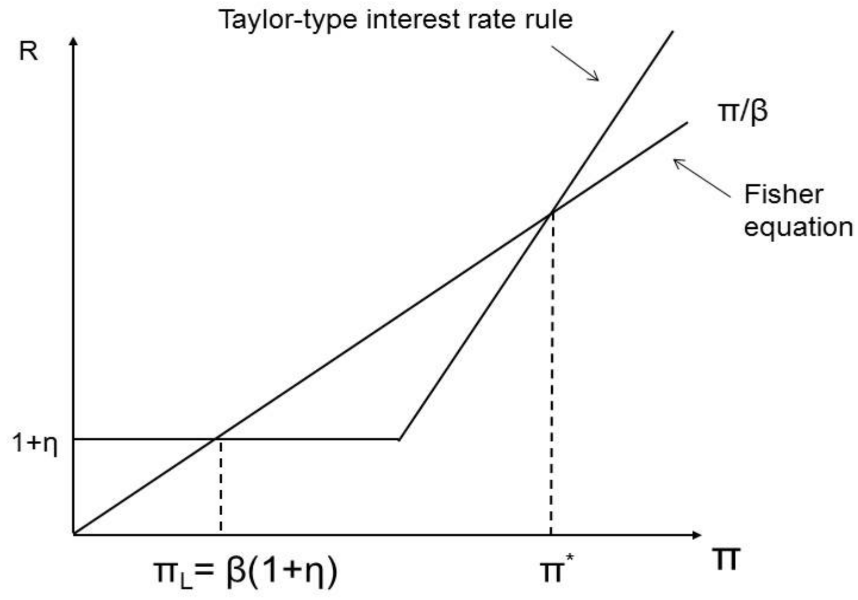

Figure 2: Taylor rule and Fisher equation.

Lower bounds on π and C

- The large negative output gap in the US (and elsewhere), starting 2008-9, led to a smaller drop in inflation than is consistent with the Phillips curve. This was also noticed in the US in the 1930s. In Japan since the mid 1990s inflation became stuck at a mild deflation rate despite stagnation.

- Various explanation are possible, e.g. downward wage rigidity or money illusion. We proceed by imposing a lower bound at some $\underline{\pi} < \pi^*$. The value of $\underline{\pi}$ might vary across countries and time periods.

- We also impose a lower bound on consumption $\underline{C}$, arising from a socially determined subsistence level. (Stone-Geary preferences would be similar).

- The $\underline{\pi}, \underline{C}$ bounds can play a stabilizing role at the ZLB.

Temporary equilibrium with lower bounds

- Given expectations, determine whether or not (and when) the ZLB is expected to hold in the future. Impose this in consumption function.

- Then given expectations solve for temporary equilibrium π, C, Y.

- If π or C would violate a lower bound then it is imposed and the temporary equilibrium is re-solved.

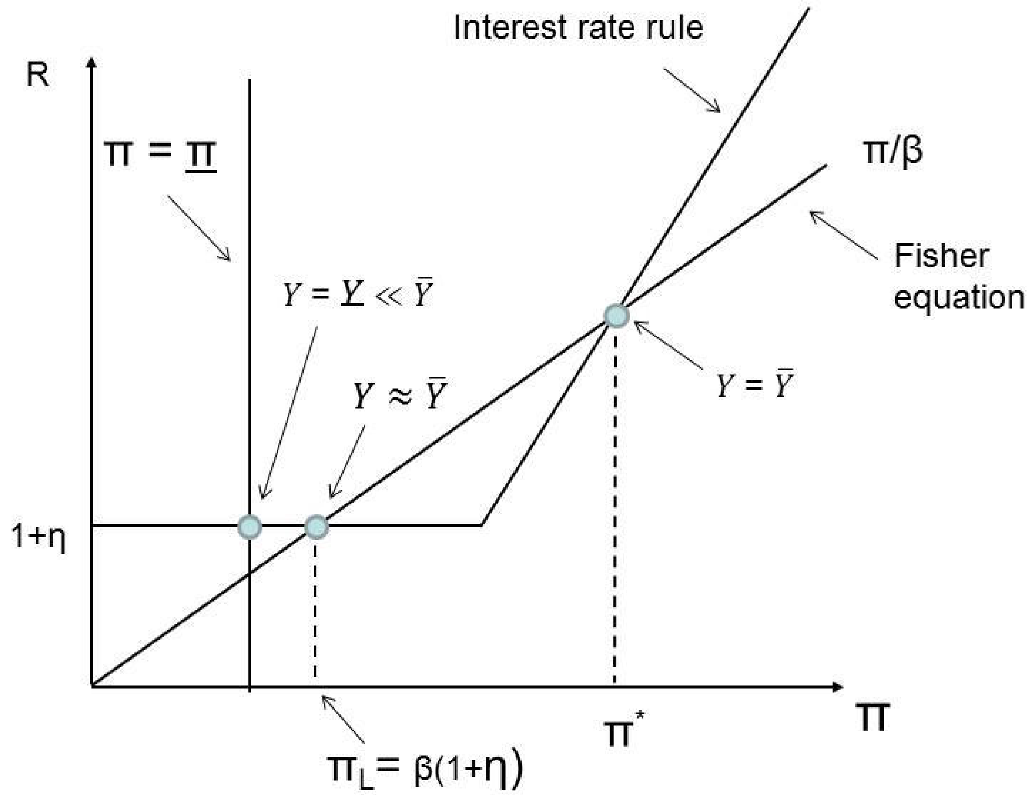

Figure 3: Existence of multiple steady states.

Multiple steady states and local stability under learning

- We obtain analytical existence and learning stability results.

- If $\underline{\pi} > \pi_L \simeq \beta$ then there is a unique steady state at π^* and it is stable under learning.

- If $\underline{\pi} < \pi_L$ then there are three steady states, with a stagnation steady state at $(\underline{\pi}, \underline{C})$.

- The π^* steady state is locally stable under learning and the π_L steady state is unstable under learning.

- The stagnation steady state is also locally stable under learning.

- The learning dynamics are mainly driven by the intercepts $f' = (f_\pi, f_Y)$ of the perceived law of motion.

- Learning stability dynamics can be obtained using the E-stability techniques of Evans and Honkapohja (2001).

- Figure shows global expectation dynamics. A large pessimistic expectation shock can lead under learning to the trap steady state.

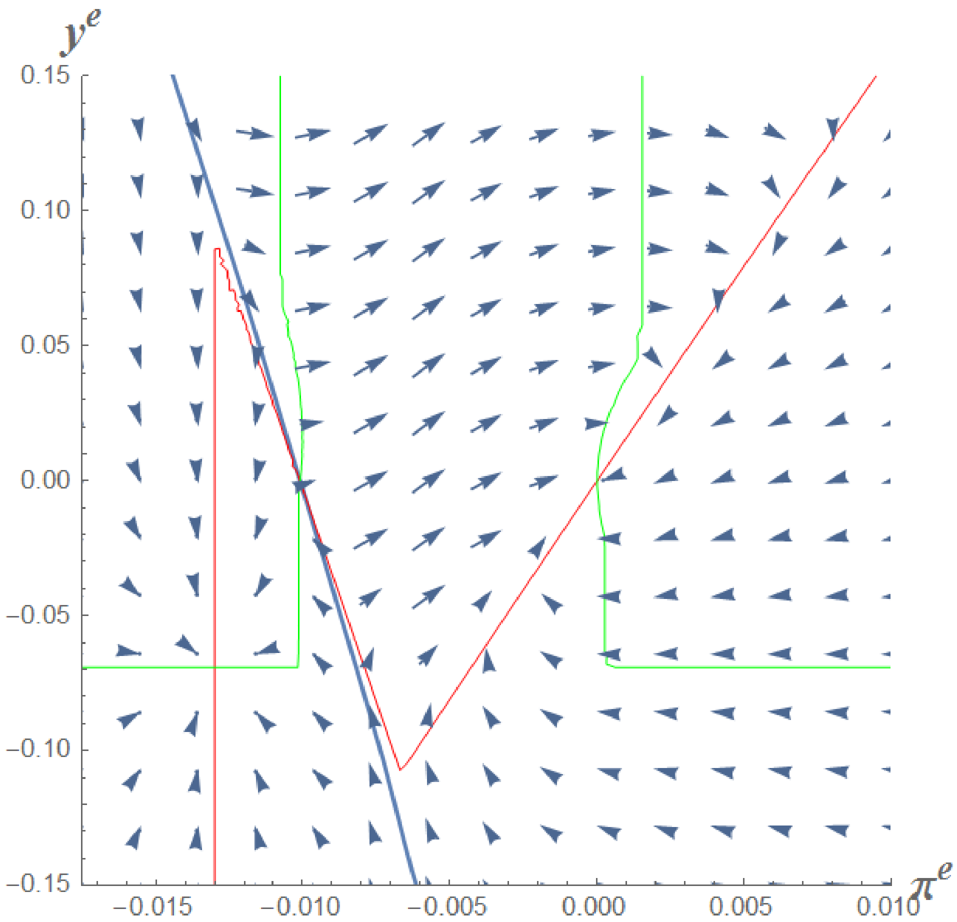

Figure 4: Learning stability dynamics with three steady states. y^e and π^e denote $\hat{Y}^e$ and $\hat{\pi}^e$.

4. Fiscal Policy

- There is a large recent literature on fiscal policy and government spending multipliers. The renewed interest reflects the US and other fiscal stimulus programs during the Great Recession.

- Most of this literature has assumed RE. We will instead assume AL.

- Consider a temporary fiscal stimulus, starting from $G_t = \bar{G}$ for $t \leq 0$, with $G_t = \tau_t = \begin{cases} \bar{G}', \; t = 1, ..., T \\ \bar{G}, \; t \geq T + 1 \end{cases}$, and $\bar{G}' > \bar{G}$.

- Assume the announcement is **fully credible and actually implemented**.

- We compute both distributed lag and cumulative multipliers

$$ym_t = \frac{Y_t - Y_t^{np}}{(\bar{G}' - \bar{G})/\bar{Y}} \text{ and } ycm_t = \frac{\sum_{i=1}^{t} \beta^{i-1}(Y_i - Y_i^{np})}{(\bar{G}' - \bar{G})/\bar{Y} \sum_{i=1}^{T} \beta^{i-1}}, \text{ for } t = 1, 2, 3, \ldots,$$

  Because of discounting the cumulative multiplier will be finite even in those cases considered below in which policy leads to a permanent change in the level of output. In the formula above, Y_i^{np} denotes the level of output in period i in the absence of a policy change.

- Agents can compute $\sum_{s=0}^{\infty} \beta^s \hat{E}_t \hat{G}_{t+s}$, but they do not know the general equilibrium effects of these changes. They forecast future Y, π using AL.

Fiscal Policy in Normal Times

We start with "normal times" in which the economy is at the targeted steady state and the exogenous shocks are sufficiently small so that the ZLB for R_t rarely binds.

We use a standard quarterly calibration, i.e.

$$\begin{aligned} \alpha &= 0.66, \beta = 0.99, \theta = 7.67, \tau = 0, \epsilon = 2, \gamma = 1, \psi = 128.8, \\ \bar{G} &= 0.2, \rho_A = \rho_\mu = 0.8, \sigma_A = \sigma_\mu = 0.0033. \end{aligned}$$

We set $\pi^* = 1.005$ (2% $p.a.$) and set $\chi_\pi = 1.5$ and $\chi_Y = 0$.

A 5% increase in $\bar{G}$ for $T = 10$ results in mean paths shown in the Figure.

The main findings are that, compared to RE:

- impact on π is initially lower,

- impact on y is front-loaded;

- impact on y partially reversed after the increase in G ceases.

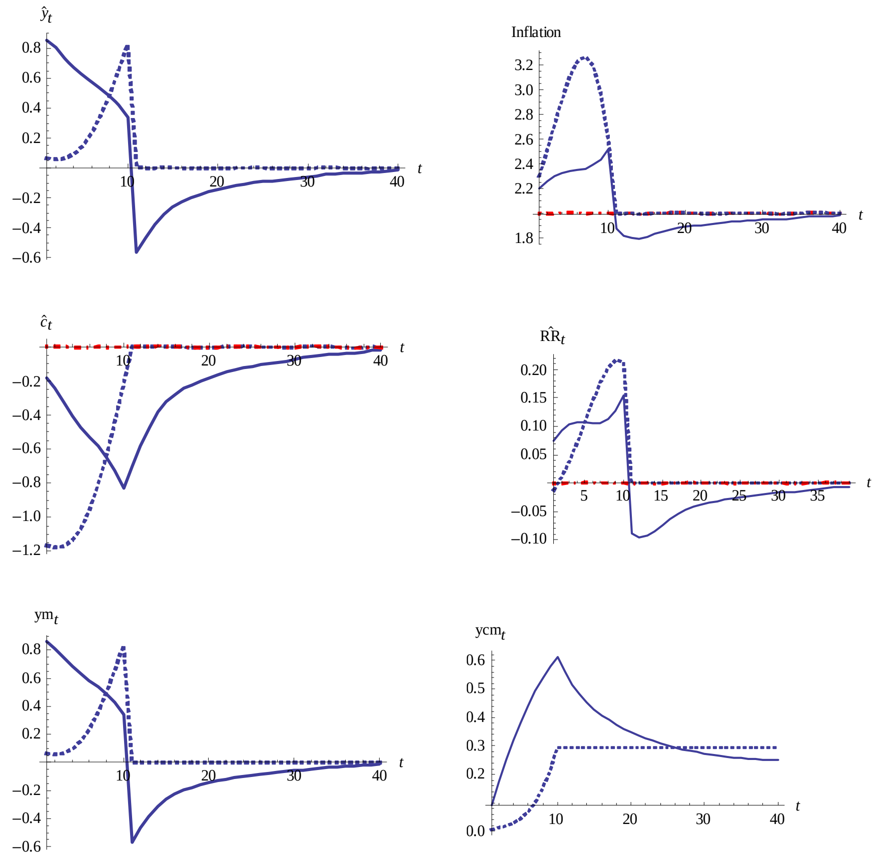

Figure 5, normal times: Upper panel: $\hat{Y}$ and inflation, in %, under RE (dotted line) and learning (solid line). Middle: $\hat{c}$ and $\hat{R}_t - \hat{E}_t \pi_{t+1}$. Lower: distributed lag and cumulative output multipliers.

Policy simulations with large pessimistic shocks

- We now consider fiscal policy taking into account the ZLB and the lower bounds $\underline{\pi}$ and $\underline{C}$.

- The impact of fiscal policy will depend on the non-stochastic components $f_\pi(0)$ and $f_y(0)$ of initial expectations $\pi^e(0)$ and $y^e(0)$.

- We use the conventional $\beta = 0.99$ so $\pi_L \approx -0.99\%$ per quarter (deflation around 4% per year) and set the lower bound at $\underline{\hat{\pi}} = -0.017$ per quarter (deflation around 4.8% per year). We also set $\underline{C}$ low, at about 30% below the normal steady state. In the stagnation steady state Y is 24% below the targeted steady state value.

- These values are extreme (Great Depression levels) but they allow us to look at the effectiveness of fiscal policy in extreme cases.

- Suppose there is a pessimistic expectations shock:

$$\pi^e \approx -1.0\% \text{ per quarter and } \hat{y}^e \approx -1.5\%,$$

  and we look at the path with and without policy if $\bar{G}$ is increased 10% from $\bar{G} = 0.20$ to $\bar{G} = 0.22$ for $T = 40$ periods. We now set $\kappa = 0.10$.

- Without policy the economy sinks to the stagnation steady state. With policy, output is temporarily raised but again goes to the stagnation state. Multipliers are larger than in normal times.

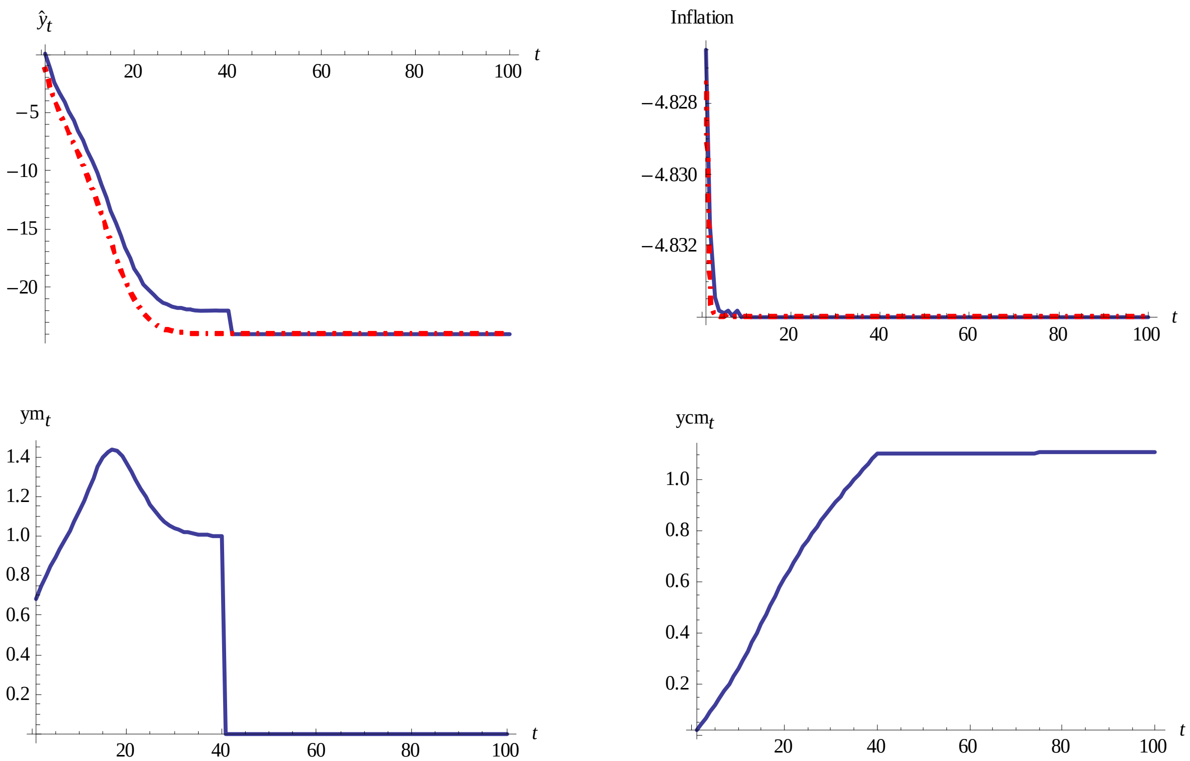

Figure 6: Small policy change for $T = 40$ periods. Upper panel: $\hat{Y}$ and $\hat{\pi}$ under learning with policy change (solid line) and without (dashed line). Lower panel: distributed lag and cumulative multipliers.

- The next Fig. starts with the same pessimistic shock and considers a large increase from $\bar{G} = 0.20$ to $\bar{G}' = 0.28$ for $T = 4$ periods. Top: means of paths converging to π^* under policy. Middle: means of paths converging to trap despite policy. Bottom: multipliers across all paths.

- Now in 99.6% of simulations the economy escapes the trap and returns to the targeted steady state.

- Cumulative multipliers are very large due to the stimulus usually pushing the economy out of the deflation trap. The 40-period cumulative multiplier is about 19.

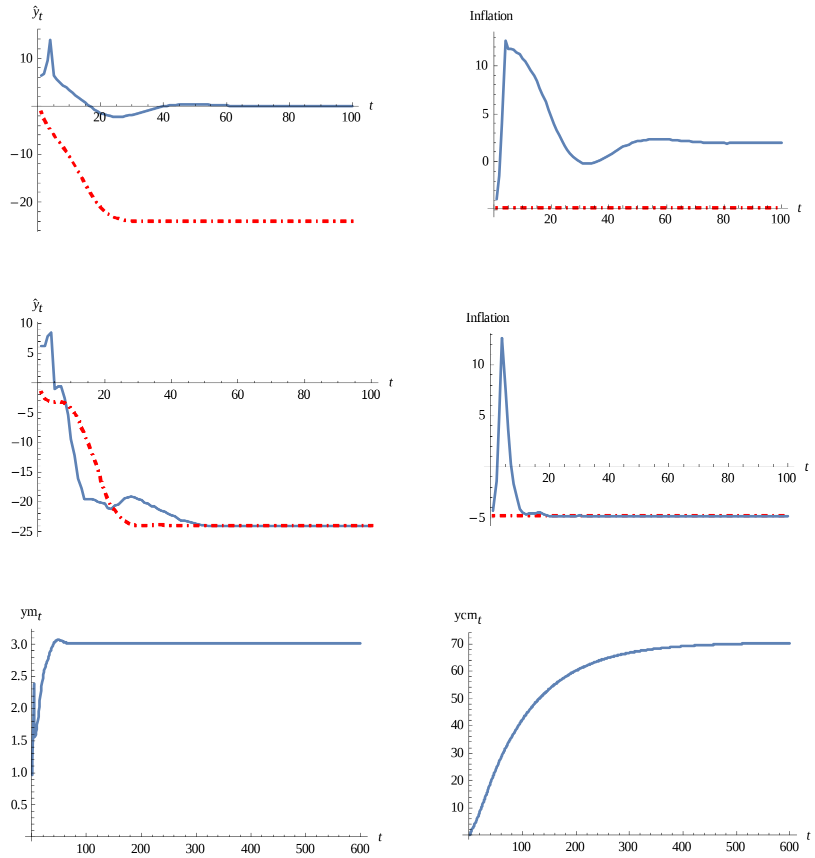

Figure 7: Large policy change $T = 4$. Top: paths under learning with (solid line) and without (dashed line) policy change escaping the trap with policy. Middle: paths for other cases. Bottom: multipliers.

- Using the same initial pessimistic expectations, we vary the size and length of the fiscal stimulus.

- Table 1 shows that a large short stimulus has a higher probability of success (return to π^* steady state) than a smaller longer stimulus.

- Table 2 shows the 40 period cumulative multipliers. For moderate-sized stimuli with T not too large the multipliers are large.

$G\backslash T$	1	2	3	4	5	10	20	40
0.22	0	0	0	0	0	0	0	0
0.24	2	12	16	22	21	13	3	0
0.25	23	53	64	58	49	32	14	0
0.27	88	100	100	100	99	86	99	10
0.28	98	100	100	100	100	96	70	14
0.30	100	100	100	100	100	100	100	39
0.35	100	100	100	100	100	100	97	99
0.40	100	100	100	100	100	98	92	100
0.50	100	100	100	99	98	86	39	49
0.60	100	100	100	99	95	59	21	2
1.0	100	98	89	56	42	9	2	2
2.0	95	30	7	6	3	2	0	0

Table 1: Percentage of simulations in which fiscal policy successfully results in convergence to the targeted steady state starting from pessimistic expectations. Based on 100 simulations.

$G\backslash T$	1	2	3	4	5	10	20	40
0.22	4.6	3.1	2.6	2.3	2.2	2.2	1.5	1.1
0.24	12.6	14.6	11.6	11.1	8.4	3.6	1.7	1.1
0.25	36.8	35.9	27.9	19.4	14.0	5.4	2.2	1.1
0.27	76.2	43.1	29.0	21.9	17.5	8.1	17.5	1.3
0.28	73.5	37.8	25.4	19.2	15.4	7.7	3.4	1.4
0.30	59.9	30.2	20.3	15.3	12.4	6.4	3.4	1.5
0.35	40.0	20.2	13.6	10.2	8.3	6.9	2.3	1.6
0.40	30.0	15.1	10.2	7.7	6.2	3.2	1.7	1.3
0.50	20.0	10.1	6.8	5.2	4.0	2.0	1.2	1.0
0.60	15.0	7.6	5.0	3.7	2.9	1.4	1.0	1.0
1.0	7.4	3.5	2.1	1.4	1.1	0.9	0.9	0.9
2.0	2.9	1.0	0.7	0.7	0.8	0.9	0.9	1.0

Table 2: Cumulative multipliers through $t = 40$ for fiscal policies starting from pessimistic expectations. Based on 100 simulations.

Case of unique steady state

- Suppose the inflation lower bound $\underline{\pi}$ corresponds to -0.98% per quarter (which is just above $\pi_L = -0.99\%$ per quarter). Consider the pessimistic expectations shock

$$\text{net } \pi^e \approx -1.2\% \text{ per quarter and } \hat{y}^e \approx -1.0\%.$$

- Now there is a unique steady state at π^*. Pessimistic expectations can still lead to a long and deep recession. Fiscal policy remains effective in raising output and speeding the recovery. The next Figure gives results for increasing $\bar{G}$ by 20% for $T = 40$.

- Cumulative multipliers are smaller than those in Table 2, but still quite large. Note the economy is initially at the ZLB.

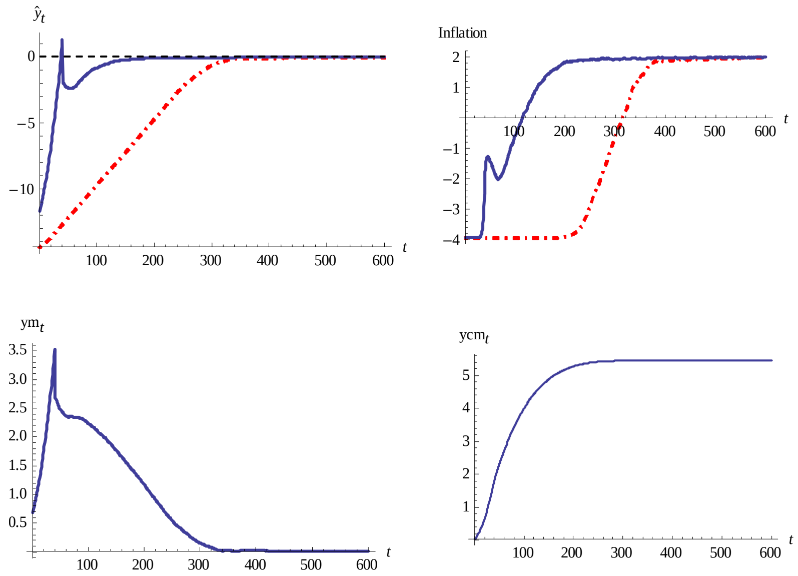

Figure 8: Policy change when there is a unique steady. Top: paths under learning with policy change (solid line) and without policy change (dashed line). Bottom: multipliers.

5. Further Results

Escape from stagnation

- Suppose fiscal policy is not implemented until, following a large pessimistic shock, the economy has already converged to a stagnation steady state at the level of the 1930s Great Depression in the US.

- Can a suitable fiscal stimulus still return the economy to the targeted steady state?

- Table 3 gives the results for our calibration. The right size and length of stimulus can still be effective, but it must now be very large. For example, three years at $G = 0.7$ has a success rate of 82%.

$G \backslash T$	1	2	3	4	5	6	7	8	12	16	20
0.4	0	0	0	0	0	0	0	0	0	0	0
0.5	0	0	0	0	0	0	0	0	0	3	43
0.7	0	0	0	1	6	19	47	60	82	60	37
0.8	0	0	1	13	53	77	86	89	63	33	25
0.9	0	1	29	68	85	90	88	81	36	17	11
1.0	0	14	66	87	90	91	80	60	20	9	5
1.2	0	73	91	88	79	61	44	31	4	4	3
1.5	58	89	84	62	33	22	11	9	1	2	1
1.7	76	88	72	32	16	10	6	6	2	1	0
2	83	66	30	13	6	5	4	2	3	0	0
2.5	81	33	8	3	1	4	3	4	1	0	0

Table 3: Percentage of simulations in which fiscal policy successfully results in convergence to the targeted steady state starting from stagnation expectations. Based on 100 simulations.

Results with high discount factor

- Calibration of β: we have used the usual quarterly value $\beta = 0.99$.

- But the real return on US T-bills since 1946 is less than 1% *per year.* This suggests a much higher value is plausible, e.g. $\beta = 0.995$ or $\beta = 0.9975$.

- The value of β matters: for $\beta = 0.99$ quarterly, the critical inflation rate π_L corresponds to 4% per year deflation. Actual deflation in Japan and Europe, as well as the US even in 2009-10 has been above this value.

- But for $\beta = 0.995$ or 0.9975 the critical deflation rate is 2% or 1% per annum, in line with values occasionally observed in Japan in the 1990s and sometimes threatened in the euro area.

- The next figure looks at simulations with $\beta = 0.9975$. We set $\underline{\pi}$ corresponding to deflation at about 1.4% per year, and consider initial π^e at this level, following a presumed pessimistic shock, along with expected output 1% below the targeted steady state.

- Without fiscal policy the economy descends into the stagnation state. If G increased from $G = 0.20$ to $G = 0.35$ for $T = 2$ quarters, 98.6% of paths (top panel) converge to the intended steady state, while 1.4% eventually sink to the stagnation state.

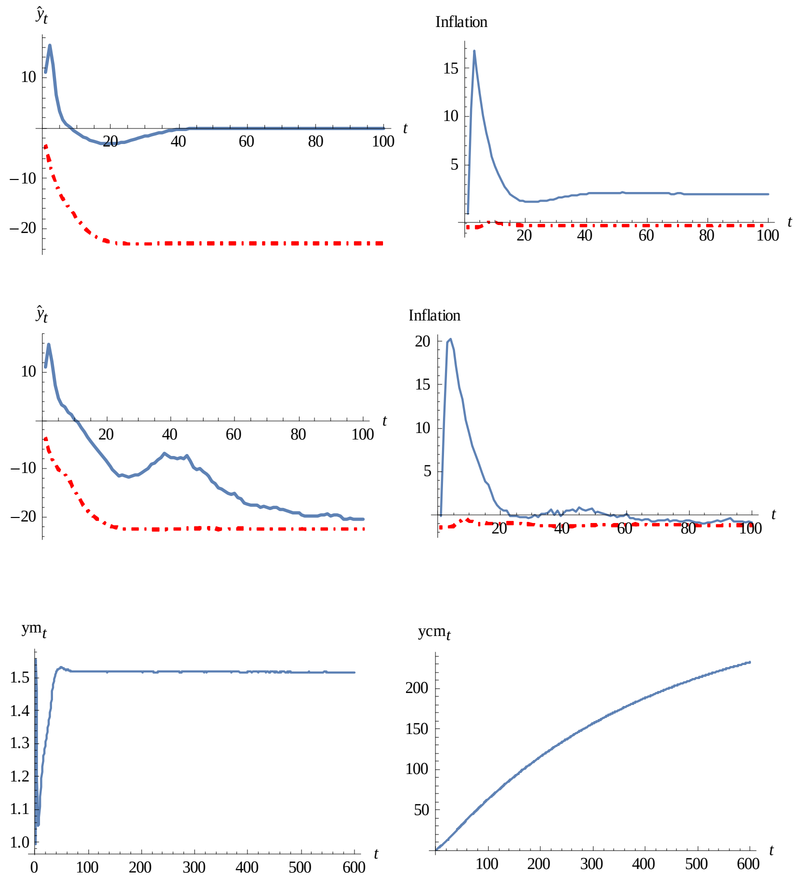

Figure 9: High discount factor, $\beta = 0.9975$.

Credit frictions

- Another factor that can increase the critical inflation rate, below which stagnation can occur, is the existence of credit frictions that lead to a borrowing rate higher than the lending rate.

- Curdia and Woodford (2010, 2015) model this using a heterogeneous agents setup. At the aggregate level the interest rate R in the household Euler equation is above the policy rate i.

- We use the Woodford (2011) shortcut and set $R = i + \varphi$ with $\varphi > 0$.

- For β near one and $\varphi > 0$ the critical inflation rate can be zero or positive. (For large $\varphi > 0$ only the stagnation steady state exists).

- We set $\beta = 0.9975$ and $\varphi = 0.0025$, a spread of 1% per year in line with Curdia and Woodford (2015). The critical inflation rate is just over zero.

- In Figure 10 we consider initial expectations

$$\text{net } \pi^e \approx 0.1\% \text{ per year and } \hat{y}^e \approx -5\%.$$

- Without fiscal policy over 73% of the paths converge to the stagnation steady state (while 25% go to the targeted steady state).

- Increasing G from 0.20 to 0.38 for $T = 2$ periods $\longrightarrow$ 86% of the paths go to the targeted steady state (11% go to the stagnation state).

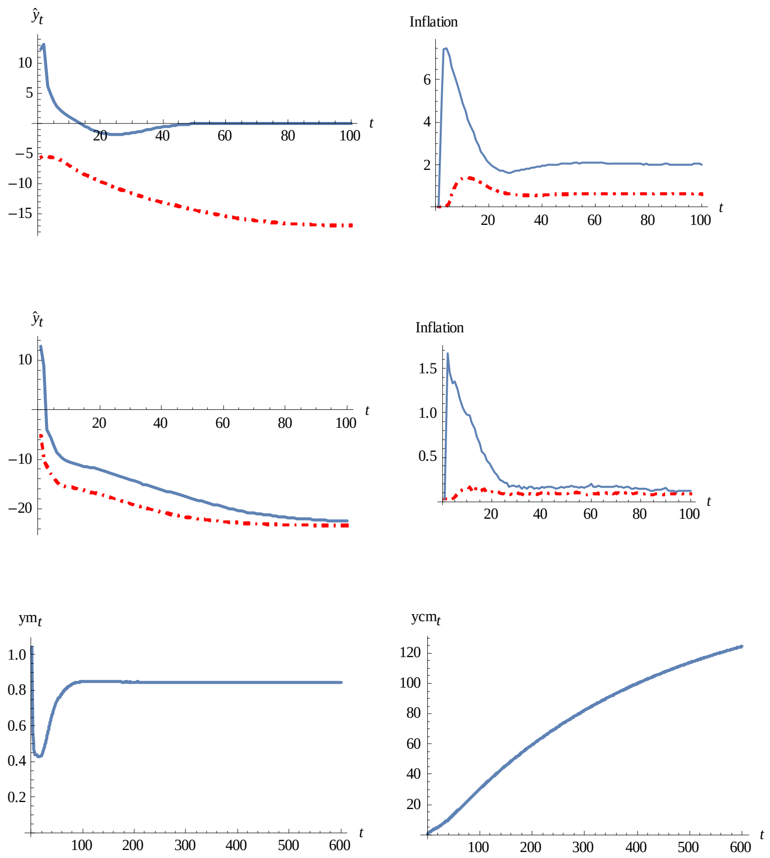

Figure 10: Credit spread case.

Wage rate and profit forecasting

- In the consumption function we followed Eusepi and Preston (2010) in assuming households forecast their future before tax income.

- An alternative: households forecast wage rates and profit income and assume they can choose hours at the forecasted wage. This alternative assumption is more in line with the microfoundations of the model, but we find the income forecasting approach more natural in practice.

- We reworked the model with wage rate and profit forecasting, and compared simulations for the case of "normal times." We found only slight quantitative differences from the results obtained using income forecasting.

6. Discussion and Conclusions

- – The RE literature has mostly emphasized a large fundamental preference or credit-spread shock that leads households to reduce consumption. The shock is exogenous and evaporates with a constant probability each year.
  – We start instead with the crisis of confidence: a large pessimistic expectations shock to π^e, Y^e triggered by events like arising from the 2007-9 financial crisis.

- Our model with adaptive learning includes the possibility of a deflation trap in which there is convergence to deflation and stagnation.

- Calibration of the discount rate β is important because $\pi_L \approx \beta$. If a credit spread $\varphi > 0$ is present then $\pi_L = \beta + \varphi$, which can correspond to zero or even to positive inflation.

- The main policy messages:

  (i) If there is a large pessimistic shock to expected inflation and output, aggressive monetary easing should be followed.

  (ii) However, an aggressive fiscal stimulus may also be needed to avoid the stagnation steady state or a long period of recovery.

  (iii) Even positive but persistently below target inflation and inflation expectations raise the possibility of entering a stagnation trap.

  (iv) An early fiscal stimulus can be *much* better than waiting.

- More generally (i) our model shows that under AL fiscal multipliers are heavily nonlinear and state dependent, and (ii) the model is quite rich in terms of the economic outcomes possible after a large pessimistic shock.