Empirical Properties of Inflation Expectations and the Zero Lower Bound

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Introduction

- In New Keynesian models with a zero lower bound, movements in household inflation expectations are of great importance for the amplification of shocks and the effectiveness of policy.

$$c_{i,t} = E_t \left[-\frac{1}{\gamma} \left(r_t - \pi_{t+1} \right) + c_{i,t+1} \right]$$

- It is therefore desirable to model inflation expectations in a way that is consistent with data.
- Properties of inflation expectations in those models are quite different from properties of survey data on inflation expectations.

Introduction

- Properties of inflation expectations in *any* model with rational expectations and perfect information:
  1. All agents have the same expectation of aggregate inflation.
  2. The inflation expectation responds instantly to realized shocks to future inflation.

- Properties of survey data on inflation expectations:
  1. Individuals report heterogeneous inflation expectations.
  2. The average inflation expectation responds slowly to realized shocks to future inflation. (Coibion-Gorodnichenko, 2012)

Introduction

- New Keynesian model with dispersed information on household side
  $\Longrightarrow$ Slow adjustment and heterogeneity of HH inflation expectations

- Questions:
  Dynamics at ZLB?
  Effects of monetary policy at ZLB?
  Effects of fiscal policy at ZLB?

Introduction

- Theoretical literature on ZLB: Eggertsson and Woodford (2003), ..., Kiley (2014), Andrade, Gaballo, Mengus, and Mojon (2015)
- Empirical literature on inflation expectations: Mankiw, Reis, and Wolfers (2004), Armantier, Bruine de Bruin, Topa, van der Klaauw, and Zafar (2011), Coibion and Gorodnichenko (2012, 2015)
- Business cycle models with imperfect information on household side: Mankiw and Reis (2006), Lorenzoni (2009), Angeletos and La'O (2013), Maćkowiak and Wiederholt (2015)

Model

- There is a continuum of households of mass one, indexed by $i \in [0, 1]$.
- Preferences of an individual household:

$$E_0^i \left[\sum_{t=0}^{\infty} \beta^t e^{\xi_{i,t}} \left(\frac{C_{i,t}^{1-\gamma} - 1}{1-\gamma} - N_{i,t} \right) \right]$$

Model

- In period zero, each household is hit by a preference shock:

$$\xi_{i,0} \in \{\xi_L, \xi_H\} \quad \text{with} \quad \xi_L < \xi_H < 0$$

  Let λ denote the mass of households with $\xi_{i,0} = \xi_H$.

- There are two possible aggregate states:

$$\lambda \in \{\lambda_{bad}, \lambda_{good}\} \quad \text{with} \quad 0 < \lambda_{bad} < \lambda_{good} < 1$$

- In the following periods, all preference shocks either do not change or revert permanently back to zero.

$$\Pr\{\xi_{i,t} = \xi_{i,t-1}\} = \mu, \quad \Pr\{\xi_{i,t} = 0\} = 1 - \mu$$

  Let T denote period when all preference shocks revert back to zero.

Model

- Households can save or borrow by holding nominal government bonds.
- Households can trade state-contingent claims in period minus one. These claims are settled in period T.
- Bond holdings of household i between periods t and $t+1$:

$$B_{i,t} = R_{t-1} B_{i,t-1} + W_{i,t} N_{i,t} + D_{i,t} - P_t C_{i,t} + Z_{i,t}$$

- Households cannot run a Ponzi scheme.

Model

- *Perfect information*: In every period, households know the entire history of the economy up to and including the current period.

- *Imperfect information:*
  (1) In period zero, households learn the realization of their own preference shock and form beliefs about the aggregate state using Bayes' rule.
  (2) In every period $0 \leq t \leq T-1$, a constant fraction $\omega \in [0,1]$ of randomly selected households learns the realization of the aggregate state and moves to full-information rational expectations of inflation.

Model

- Competitive final-good firms with technology

$$Y_t = \left(\int_0^1 Y_{j,t}^{\frac{\psi-1}{\psi}} dj \right)^{\frac{\psi}{\psi-1}}$$

- Monopolistically competitive intermediate-good firms with technology

$$Y_{j,t} = N_{j,t}^{\varrho}, \quad N_{j,t} = \left(\int_0^1 N_{i,j,t}^{\frac{\eta-1}{\eta}} di \right)^{\frac{\eta}{\eta-1}}$$

- Final-good firms have flexible prices.
- Intermediate-good firms have sticky prices, as in Calvo (1983).
- Firms have perfect information and rational expectations.

Model

- Monetary policy rule:

$$R_t = \max\left\{1, R\Pi_t^{\phi}\right\}, \quad R = \frac{1}{\beta}, \ \phi > 1$$

- Government flow budget constraint:

$$T_t + B_t = R_{t-1} B_{t-1} + P_t G_t$$

Household and firm optimality

- Consumption Euler equation:

$$c_{i,t} = E_t^i \left[-\frac{1}{\gamma} \left(\xi_{i,t+1} - \xi_{i,t} + r_t - \pi_{t+1} \right) + c_{i,t+1} \right]$$

- New Keynesian Phillips curve:

$$\pi_t = \kappa c_t + \varkappa \left(\bar{E}_t \left[p_t \right] - p_t \right) + \beta E_t \left[\pi_{t+1} \right]$$

- Monetary policy rule:

$$r_t = \max \left\{ -\bar{r}, \phi \pi_t \right\}$$

Analytical solutions

- Assumptions:
  Households only learn from their own local conditions ($\omega = 0$)
  Households set real wage rates

- Guess:
  Consumption, inflation, and the nominal interest rate are constant over time in periods $0 \leq t \leq T - 1$. The economy is in the non-stochastic steady state with zero inflation thereafter.

Analytical solutions

- ZLB binds in all states
  - Downward movements in inflation expectations are *destabilizing*.
  - Information friction *increases* consumption in bad state.
  - Consumption choices of households are *strategic complements*.
- ZLB binds in no state
  - Downward movements in inflation expectations are *stabilizing*.
  - Information friction *decreases* consumption in bad state.
  - Consumption choices of households are *strategic substitutes*.
- ZLB binds in some states
  - Information friction *increases* consumption in bad state if real interest rate is *higher* in bad state than in good state.
  - Consumption depends on: average inflation expectation, average probability assigned to bad state, and inflation in bad state.

Analytical solutions

- When ZLB binds in both states, consumption equals

$$c_{good} = \frac{\frac{1}{\gamma}\bar{\xi}_{good} + \frac{\frac{1}{\gamma}}{1-\mu}\bar{r}}{1 - \frac{\frac{1}{\gamma}}{1-\mu}\frac{\mu\kappa}{1-\beta\mu}} - \bar{p}^{bad}_{good}\frac{\frac{\frac{1}{\gamma}}{1-\mu}\frac{\mu\kappa}{1-\beta\mu}}{1 - \frac{\frac{1}{\gamma}}{1-\mu}\frac{\mu\kappa}{1-\beta\mu}}\left(c_{good} - c_{bad}\right)$$

$$c_{bad} = \frac{\frac{1}{\gamma}\bar{\xi}_{bad} + \frac{\frac{1}{\gamma}}{1-\mu}\bar{r}}{1 - \frac{\frac{1}{\gamma}}{1-\mu}\frac{\mu\kappa}{1-\beta\mu}} + \bar{p}^{good}_{bad}\frac{\frac{\frac{1}{\gamma}}{1-\mu}\frac{\mu\kappa}{1-\beta\mu}}{1 - \frac{\frac{1}{\gamma}}{1-\mu}\frac{\mu\kappa}{1-\beta\mu}}\left(c_{good} - c_{bad}\right)$$

Numerical solutions

- Relaxing simplifying assumptions:
  Households update inflation expectations over time ($\omega \in (0, 1)$)
  Deterministic decay
  Households set nominal wage rates

Parameter values

- Preference parameters:

$$\beta = 0.99, \quad \gamma = 1, \quad \psi = 10$$

- Technology:

$$\varrho = 2/3, \quad \alpha = 0.66$$

- Preference shock parameters:

$$\xi_H = -0.05, \quad \xi_L = -0.075, \quad \mu = 0.8$$

$$\lambda_{good} = 3/4, \quad \lambda_{bad} = 1/4$$

- Slope of Phillips curve and monetary policy rule parameter:

$$\kappa = 0.045, \quad \phi = 1.5$$

- Information diffusion parameter:

$$\omega = 0.125$$

- Prior probability of good state:

$$\theta = 0.9$$

Figure 1: consumption over time, benchmark

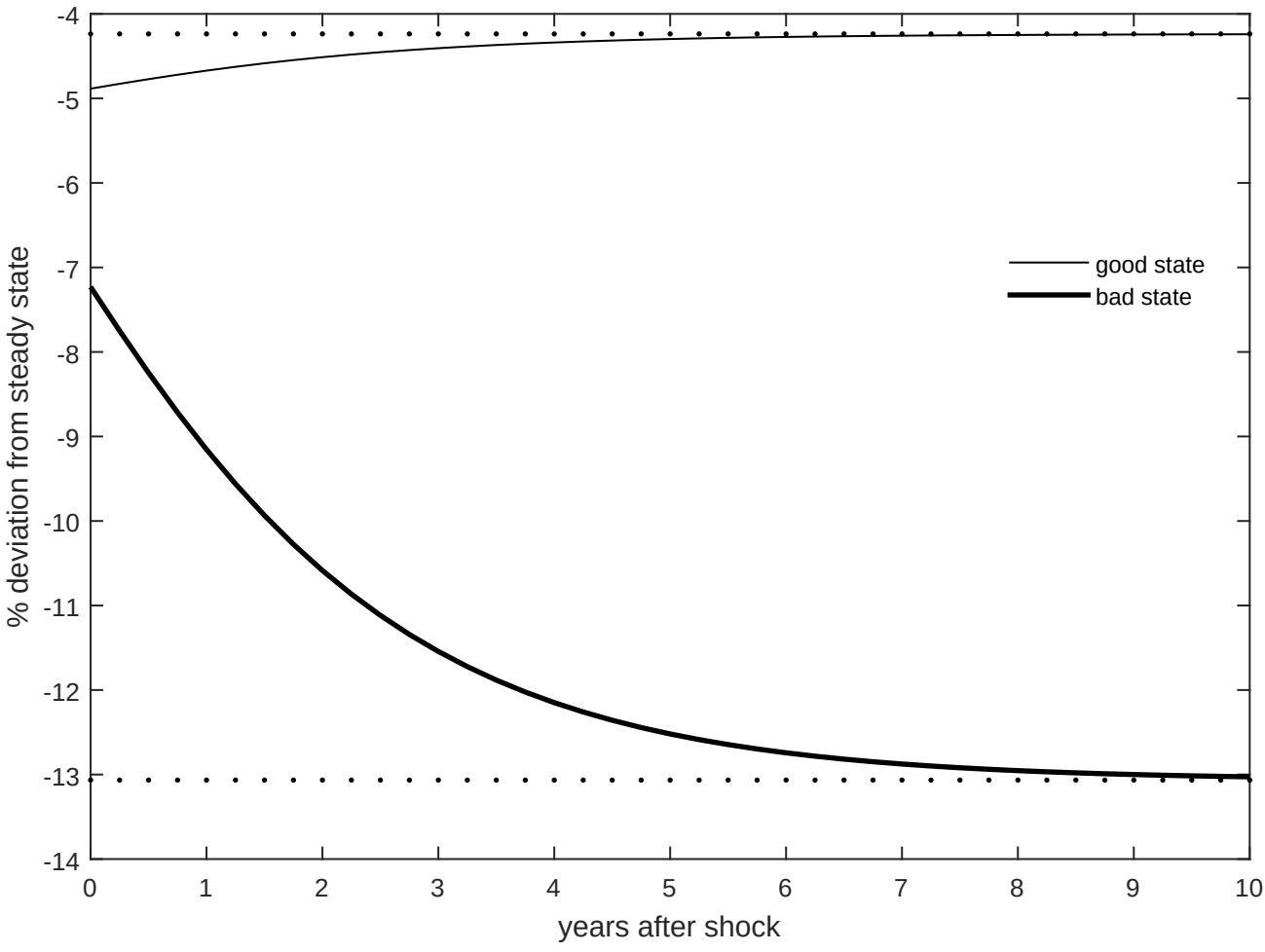


Figure 2: consumption and nominal interest rate, deterministic decay

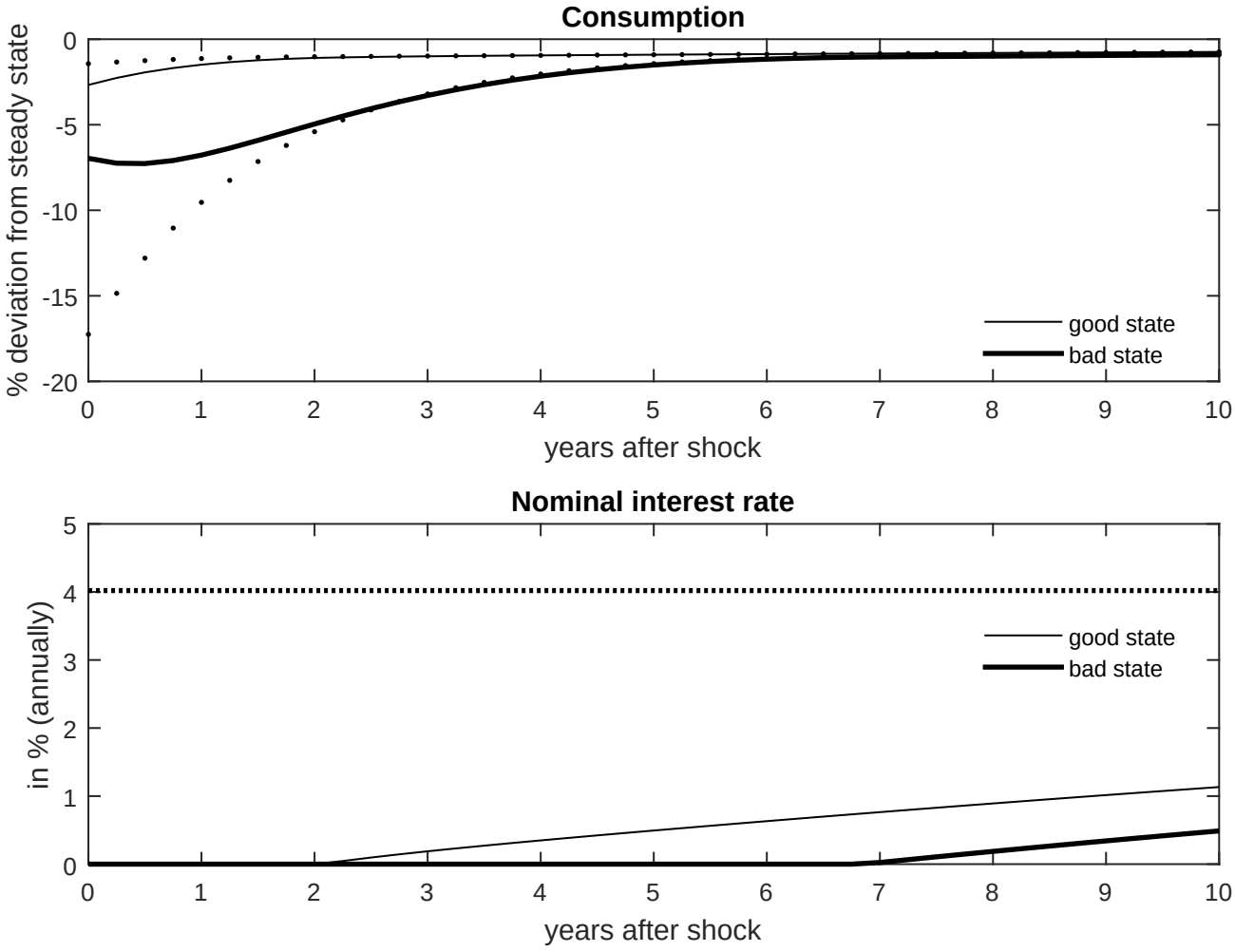
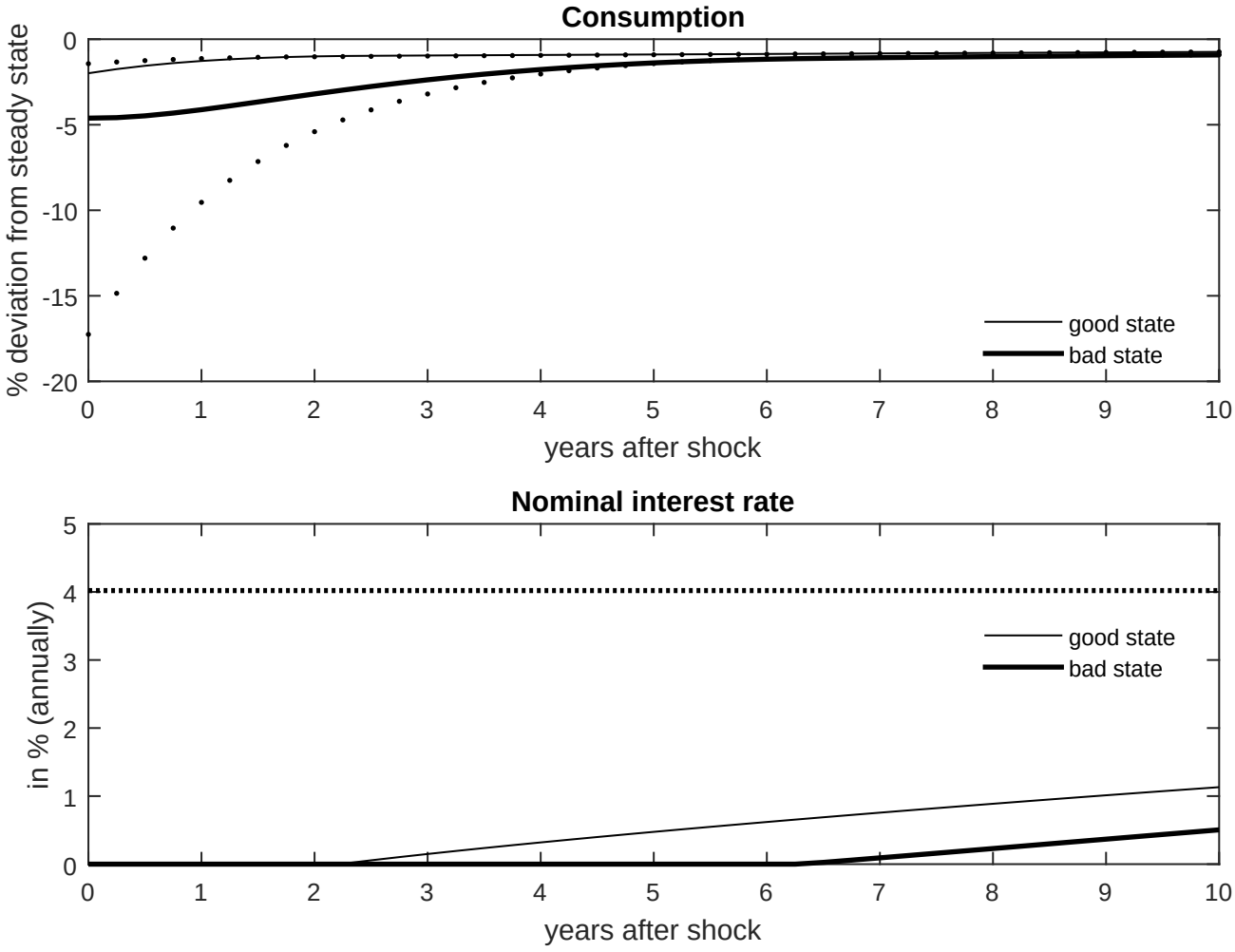


Figure 3: consumption and nominal interest rate, households set nominal wage rate



Central bank communication about current state

- In period zero, CB makes a correct statement about aggregate state of the economy. This statement reaches a fraction $\zeta \in [0, 1]$ of randomly selected households.
- Probability $\bar{p}_{bad}^{good}$ is multiplied by a factor of $1 - \zeta$.
- Consumption in bad state falls.

Forward guidance

- In period zero, CB makes a statement about future path of its policy tools. This statement reaches a fraction $\zeta \in [0, 1]$ of randomly selected households.
- In good state, CB announces: we will set the interest rate in periods $t \geq T$ so as to achieve $\pi = 0$.
- In bad state, CB announces: we will set the interest rate in periods $t \geq T$ so as to achieve $\pi = \bar{\pi} > 0$.

Forward guidance

- Consumption in bad state equals

$$c_{bad} = \frac{\frac{1}{\gamma}\bar{\xi}_{bad} + \frac{\frac{1}{\gamma}}{1-\mu}\bar{r} + \left(1-\bar{p}_{bad}^{good}\right)\left(\frac{1}{1-\beta\mu}\frac{1}{\gamma}\bar{\pi} + \bar{c}\right)}{1 - \frac{\frac{1}{\gamma}}{1-\mu}\frac{\mu\kappa}{1-\beta\mu}}$$

$$+\bar{p}_{bad}^{good}\frac{\frac{\frac{1}{\gamma}}{1-\mu}\frac{\mu\kappa}{1-\beta\mu}}{1 - \frac{\frac{1}{\gamma}}{1-\mu}\frac{\mu\kappa}{1-\beta\mu}}\left(c_{good} - c_{bad}\right)$$

Conclusion

- In New Keynesian models, movements in HH inflation expectations are of great importance for propagation of shocks and effectiveness of policy.

- Properties of survey data on inflation expectations:
  1. Inflation expectations respond slowly to shocks.
  2. Inflation expectations are heterogeneous.

- A New Keynesian model with dispersed information on household side has quite different implications for shock propagation and policy effectiveness.