The dangers of policy experiments

Initial beliefs under adaptive learning

Patrick A. Pintus[1] Jacek Suda[2] Burak Turgut[3]

[1]CNRS-InSHS and Aix-Marseille University

[2]SGH and FAME|GRAPE

[3]University of Warsaw and CASE - Center for Social and Economic Research

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Motivation

- Last 12 years
  - Global Financial Crisis
  - Recessions
  - Sovereign Debt crisis
  - COVID-19
  - decline in the natural real interest rates,
  - periods of nominal interest rate at ZLB/ELB,
  - lower inflation: $\sim 2\%$ (1999-2009) *vs* 1.2% (2010-2021) in Euroarea
- Challenges for conventional policy
- New policy instruments (temporary/permanent (?))
  - Monetary policy: credit easing, asset purchases, forward guidance,...
  - Macroprudential policy: LtV, debt-service ratio (DSR),...
  - Fiscal policy
- Discussion on policy frameworks
  - MP: π^*, IT, PLT, NGDPT, AIT,...
  - Macro-Pru: systemic risk, FSB, Basel III,IV,...

Choosing policy

- Model-based approach to choosing policies
  - build a model
  - analyze the effect of policy
  - choose the best one (criterion)
- Lucas critique
  - the outcome of policy depends on expectations
- The success of new tools/policies depends on
  - expectations
  - communication
- Expectations
  - rational expectations
  - bounded rationality
  - learning

Rational Expectations in Reality?

- Can agents have rational expectations ?
- Rational expectations
  - require detailed knowledge concerning nature of equilibrium in the economy or economic situation,
  - assume agents know
    - as much as the modeler,
    - more than the econometrician.
  - agents understand and internalize new policy
    - new instrument
    - new policy
    - new strategy

What we do

- Show the effect of expectations about policy and learning
- Model with collateral constraint
  - use a variant of Kiyotaki and Moore (1997) based on Pintus and Suda (2019).
- Replace rational expectations (RE) with *adaptive learning*.
- Calibrate/estimate the model using US data from 1975Q1-2008/10Q4 period.
- Focus on initial beliefs regarding the policy
  - effects of deviations of agents beliefs from RE
  - effects of deviations of agents beliefs from actual policy
- Compare the responses under both RE and learning for different priors.

What we find

- Initial beliefs matter a lot!
  - priors affect the evolution of beliefs,
  - ... and dynamics of endogenous variables.
- Change / introduction of new policy that reduces volatility and exposure to shocks under learning may not work if the change unannounced or unexpected
  - Agents gradually learn the structure of the economy (and the policy)
  - The transition associated with high volatility
- Learning behaviour generates time-varying dynamics in beliefs
  - it can result in deviations from RE for the system under AL

Representative agent

- A representative agent solves:

$$\max E_0^* \sum_{t=0}^{\infty} \beta^t \frac{\left[C_t - \psi \frac{N_t^{1+\chi}}{1+\chi}\right]^{1-\sigma} - 1}{1-\sigma},$$

  subject to:
  - budget constraint

$$C_t + K_{t+1} - (1-\delta)K_t + T_t Q_t (L_{t+1} - L_t) + (1+R)B_t = B_{t+1} + AK_t^{\alpha} L_t^{\gamma} N_t^{1-\alpha-\gamma}$$

  - exogenous interest rate (SOE)
- E_t^* denotes expectations at time t.
- T_t is a shortcut for land demand shock.

Borrowing constraint

- Agents face borrowing constraint

$$\tilde{\Theta}_t E_t^*[Q_{t+1}]L_{t+1} \geq (1+R)B_{t+1},$$

where

$$\tilde{\Theta}_t \equiv \Theta_t \left\{ \frac{E_t^*[Q_{t+1}]}{Q} \right\}^{\varepsilon}$$

- We allow leverage to respond to changes in the land price:
  - microfounded in simple moral hazard setting,
  - $\varepsilon > 0$ agrees with evidence in Mian and Sufi (2011) on US micro data for the 2000s.

Leverage process

- Θ_t is exogenous and subject to random shocks

$$\Theta_t = \overline{\Theta}^{1-\rho_\theta} \Theta_{t-1}^{\rho_\theta} \Xi_t.$$

  - Ξ_t: leverage shocks,
  - $\overline{\Theta}$: mean (steady-state) leverage level,
  - ρ_θ: persistence of impact of leverage shocks,
  - agents learn ρ_θ (and possibly $\overline{\Theta}$).

- Similarly T_t is subject to random shocks

$$T_t = T_{t-1}^{\rho_T} \Psi_t$$

FOCs

- Borrowers ' first-order conditions are

$$
\begin{aligned}
C_t: \quad & \Lambda_t = && \left[C_t - \psi \frac{N_t^{1+\chi}}{1+\chi}\right]^{-\sigma} \\
N_t: \quad & \psi N_t^{\chi+\alpha+\gamma} = && (1-\alpha-\gamma) A K_t^{\alpha} L_t^{\gamma} \\
L_{t+1}: \quad & T_t Q_t \Lambda_t = && \beta E_t^* [T_{t+1} Q_{t+1} \Lambda_{t+1}] + \beta\gamma E_t^* [\Lambda_{t+1} Y_{t+1} / L_{t+1}] \\
& && + \Phi_t \tilde{\Theta}_t E_t^* [Q_{t+1}], \\
K_{t+1}: \quad & \Lambda_t = && \beta E_t^* [\Lambda_{t+1} (\alpha Y_{t+1} / K_{t+1} + 1 - \delta)] \\
B_{t+1}: \quad & \Lambda_t = && \beta (1+R) E_t^* [\Lambda_{t+1}] + (1+R) \Phi_t
\end{aligned}
$$

REE

- Linearized expectational system (in log levels):

$$X_t = \mathbf{A}X_{t-1} + \mathbf{B}E^*_{t-1}[X_t] + \mathbf{C}E^*_t[X_{t+1}] + \mathbf{N} + \mathbf{D}\xi_t + \mathbf{F}\psi_t,$$

  $X'_t \equiv (c_t, q_t, \lambda_t, \phi_t, b_t, k_t, \theta_t, \tau_t)$, ξ_t and ψ_t are innovations.

- Under REE, $E^*_t = E_t$ and there exists a unique stationary equilibrium

$$X_t = \mathbf{M}^{\mathbf{re}}X_{t-1} + \mathbf{H}^{\mathbf{re}} + \mathbf{G}^{\mathbf{re}}\xi_t + \mathbf{J}^{\mathbf{re}}\psi_t,$$

  where $\mathbf{M}^{\mathbf{re}}$ and $\mathbf{H}^{\mathbf{re}}$ solve

$$\begin{aligned} \mathbf{M} &= [\mathbf{I}_8 - \mathbf{C}\mathbf{M}]^{-1}[\mathbf{A} + \mathbf{B}\mathbf{M}], \\ \mathbf{H} &= [\mathbf{I}_8 - \mathbf{C}\mathbf{M}^{\mathbf{re}}]^{-1}[\mathbf{B}\mathbf{H} + \mathbf{C}\mathbf{H} + \mathbf{N}] \end{aligned}$$

Learning

- Relax RE assumption: $E_t^* \neq E_t$.
- Agents as econometricians:
  - Endow agents with a perception of the equilibrium law of motion (PLM)

$$X_t = \mathbf{M}X_{t-1} + \mathbf{H} + \mathbf{G}\xi_t + \mathbf{J}\psi_t,$$

    - has the same VAR(1) structure as RE equilibrium, but admits $\mathbf{M} \neq \mathbf{M}^{\mathbf{re}}$, $\mathbf{H} \neq \mathbf{H}^{\mathbf{re}}$, $\mathbf{G} \neq \mathbf{G}^{\mathbf{re}}$, $\mathbf{J} \neq \mathbf{J}^{\mathbf{re}}$.
  - Agents update their "beliefs" by estimating a VAR(1).
  - Agents use PLM to form expectations

$$E_\tau X_{\tau+1} = \mathbf{M}_{\tau-1}X_\tau + \mathbf{H}_{\tau-1}$$

Learning

- Agents as econometricians:
  - Actual low of motion becomes

$$[\mathbf{I}_8 - \mathbf{C}\mathbf{M}_{t-1}]X_t = [\mathbf{A} + \mathbf{B}\mathbf{M}_{t-2}]X_{t-1} + [\mathbf{B}\mathbf{H}_{t-2} + \mathbf{C}\mathbf{H}_{t-1} + \mathbf{N}] + \mathbf{D}\xi_t + \mathbf{F}\psi_t$$

  - Assume recursive updating of the perceived law of motion

$$\begin{aligned} \Omega_t &= \Omega_{t-1} + \nu(X_t - \Omega_{t-1}Z_{t-1})Z'_{t-1}\mathbf{R}_t^{-1} \\ \mathbf{R}_t &= \mathbf{R}_{t-1} + \nu(Z_{t-1}Z'_{t-1} - \mathbf{R}_{t-1}), \end{aligned}$$

    where $Z'_t = [1, X'_t]$ and $\Omega = [\mathbf{H} \quad \mathbf{M}]$
    - OLS/RLS if $\nu_t = 1/t$,
    - constant gain if $\nu_t = \nu$.
- REE: perceived and actual laws of motions coincide.

Experiment

- Agents learn and at the onset of the recession
  - the associated matrix in PLM is $\mathbf{M}_{2008Q4}$.
  - if agents have learned/estimated ρ_θ, matrix $\mathbf{M}_{2008Q4}$ reflects that.
- Shocks and beliefs (under learning) affects financial constraint.
- Given the stochastic process, in 2008Q4 agents' perception does not match the *true* process $\mathbf{M}_{2008Q4} \neq \mathbf{M}^{RE}$.
- The actual law of motion will reflect that.

Set-up: calibration

- Calibration:
  - Model delivers average values for debt-to-GDP and land value-to-GDP ratios for the period 1996Q1- 2008Q4: $B/Y \approx 0.52$ and $QL/Y \approx 0.59$

μ	β	δ	α	γ	ε	ν
0.99	0.96μ	0.025	0.33	0.0093	0.5	0.004

- Gain parameter:
  - Constant gain learning parameter: $\nu_t = 0.004$
    (regression with forgetting half-length of 40 years).

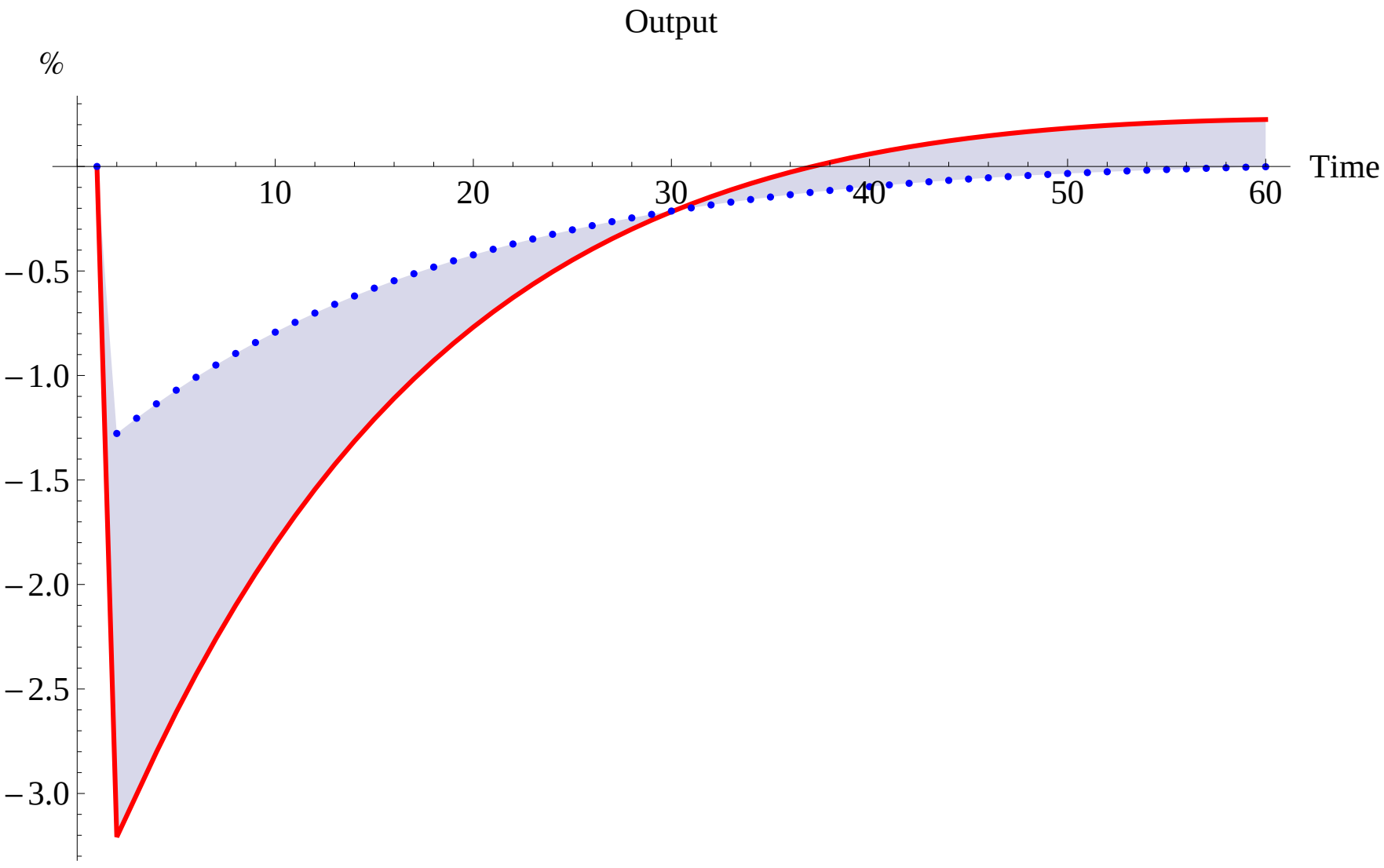
- **Start** with procyclical leverage:
  - We set $\varepsilon = 0.5$
    (calibrated from Mian and Sufi, 2011).

Impulse responses

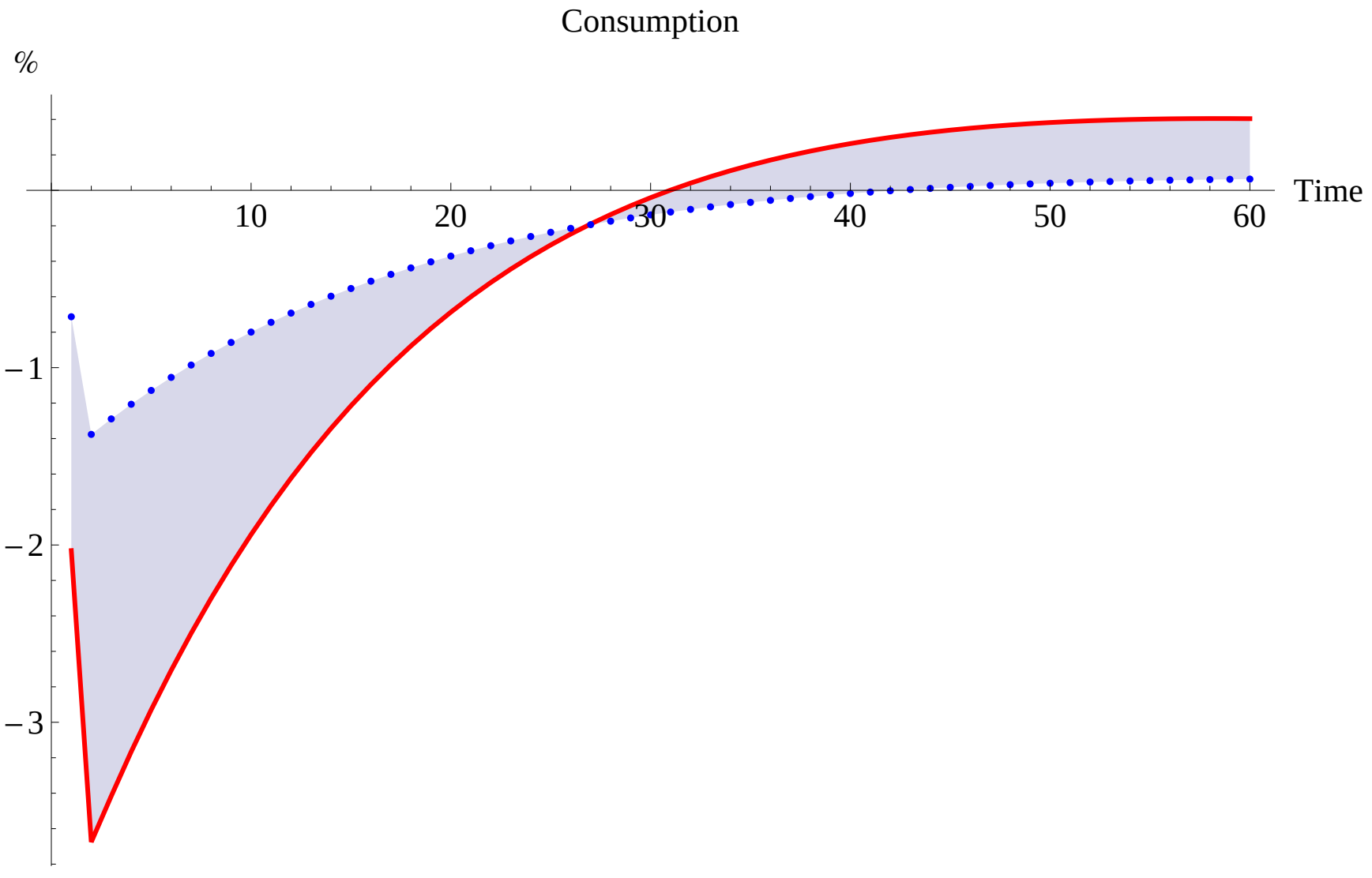
Result:

- Negative leverage shock is significantly amplified under learning
  - impact on output and capital is 2.5× larger,
  - impact on consumption is more than 3× larger.
- Deleveraging is more severe under learning
  - fall in land price is 3× larger,
  - debt decrease is multiplied by about 2.5 compared to RE.
- Both capital and output overshoot markedly their long-run levels.
- Magnitudes of output's and consumption's responses roughly match data, investment is too volatile.

Impulse responses



Impulse responses



Countercyclical leverage

What would be the effect of (macro-prudential) regulation that makes leverage mildly countercyclical ?

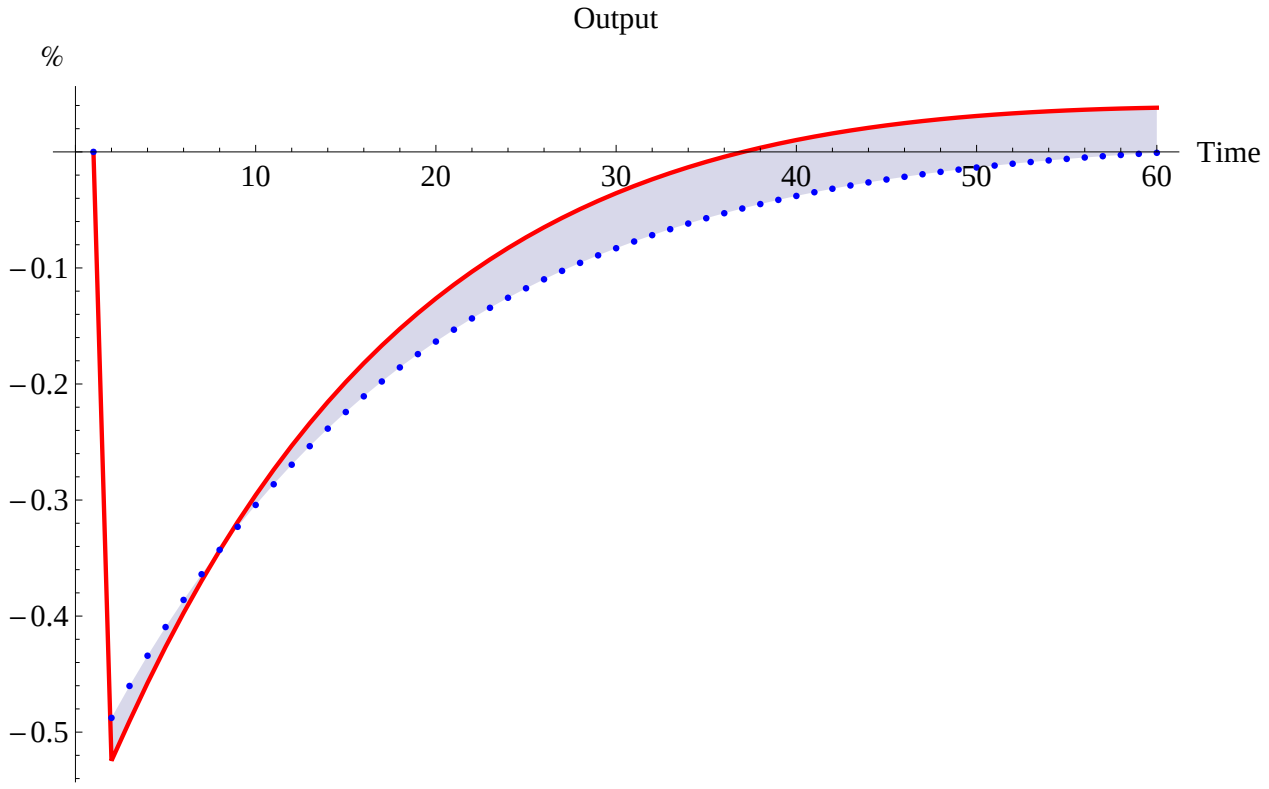
- Set $\varepsilon = -0.5$ (leverage goes down when land price goes up).

- Assume that agents "know" (or has learnt) it:
  - DGP ($\mathbf{M}^{RE}$) and beliefs ($\mathbf{M}_{2008Q4}$) use $\varepsilon = -0.5$

Countercyclical leverage

Result:

- Countercyclical leverage dampens responses to financial shocks.
- Much smaller recession follows a negative leverage shock item Countercyclical leverage brings learning dynamics closer to its rational expectations counterpart.



Countercyclical leverage

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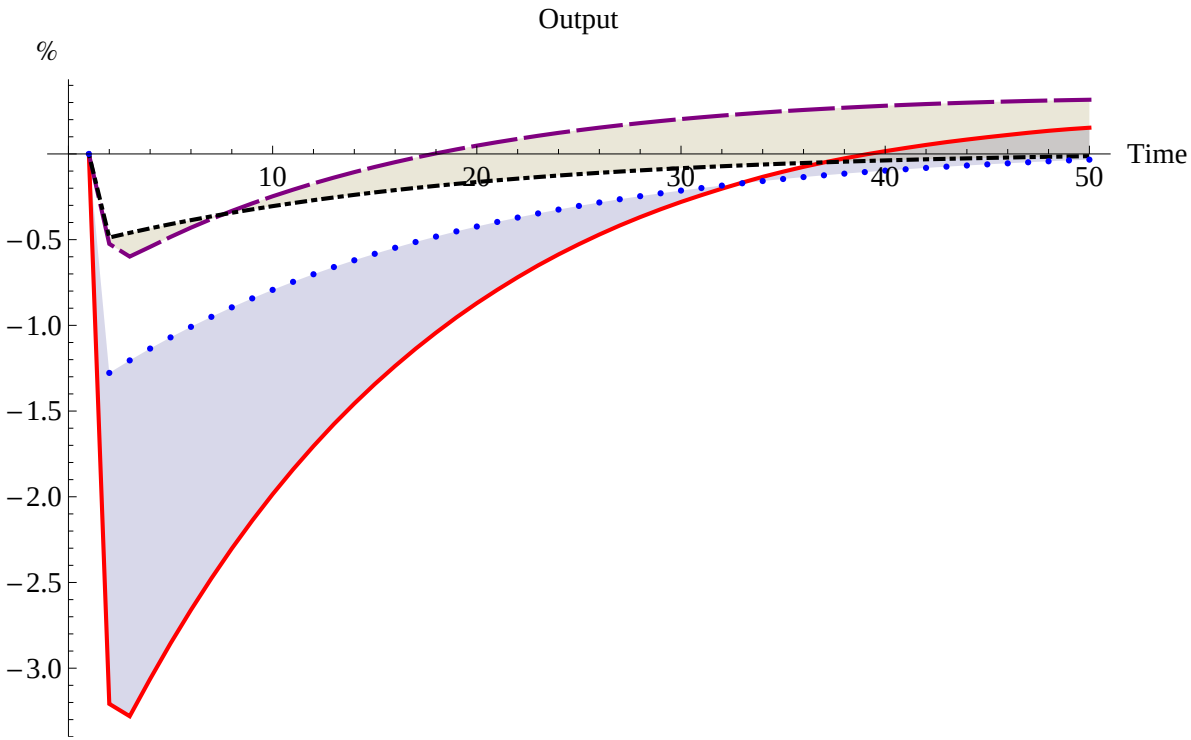
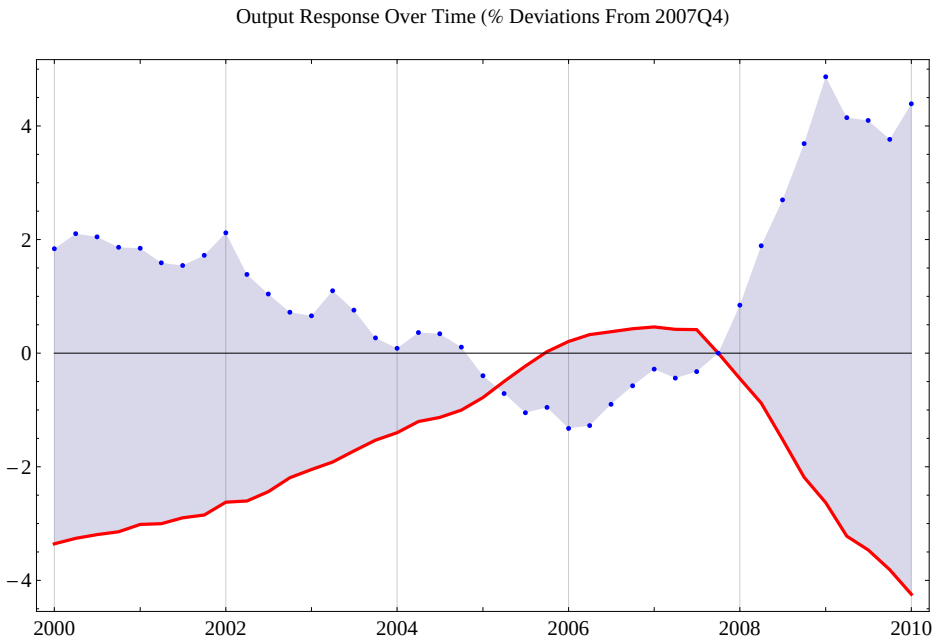


Figure: Responses to a negative leverage shocks for a pro-cyclical ($\varepsilon = 0.5$) leverage under learning (solid red) and RE (dotted blue) and for a counter-cyclical ($\varepsilon = -0.5$) leverage under learning (dashed purple) and RE (dashed-dotted black)

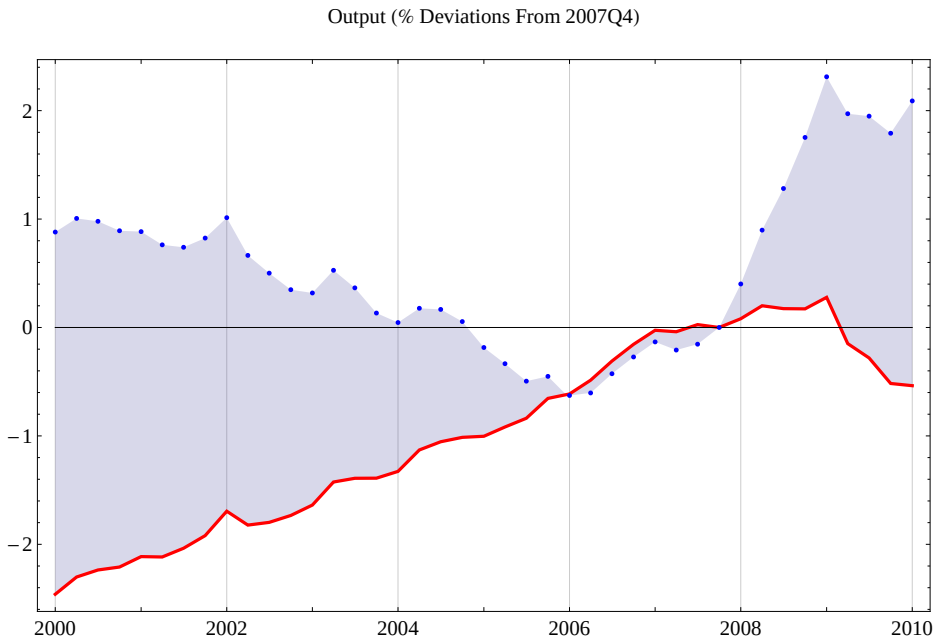
Countercyclical leverage and the Great Recession

Result:

- Countercyclical leverage could avoid Great Recession
- Much smaller recession follows a negative leverage shock



(a) Procyclical leverage, $\varepsilon = 0.5$



(b) Countercyclical leverage, $\varepsilon = -0.5$

Perception/expectations about policy

- But what if the change of policy is unannounced / not understood?
- Misperception of macroprudential policy:
  - $\mathbf{M}^{RE}$ for $\epsilon < 0$ but $\mathbf{M}_{2008Q4}$ reflects $\epsilon > 0$

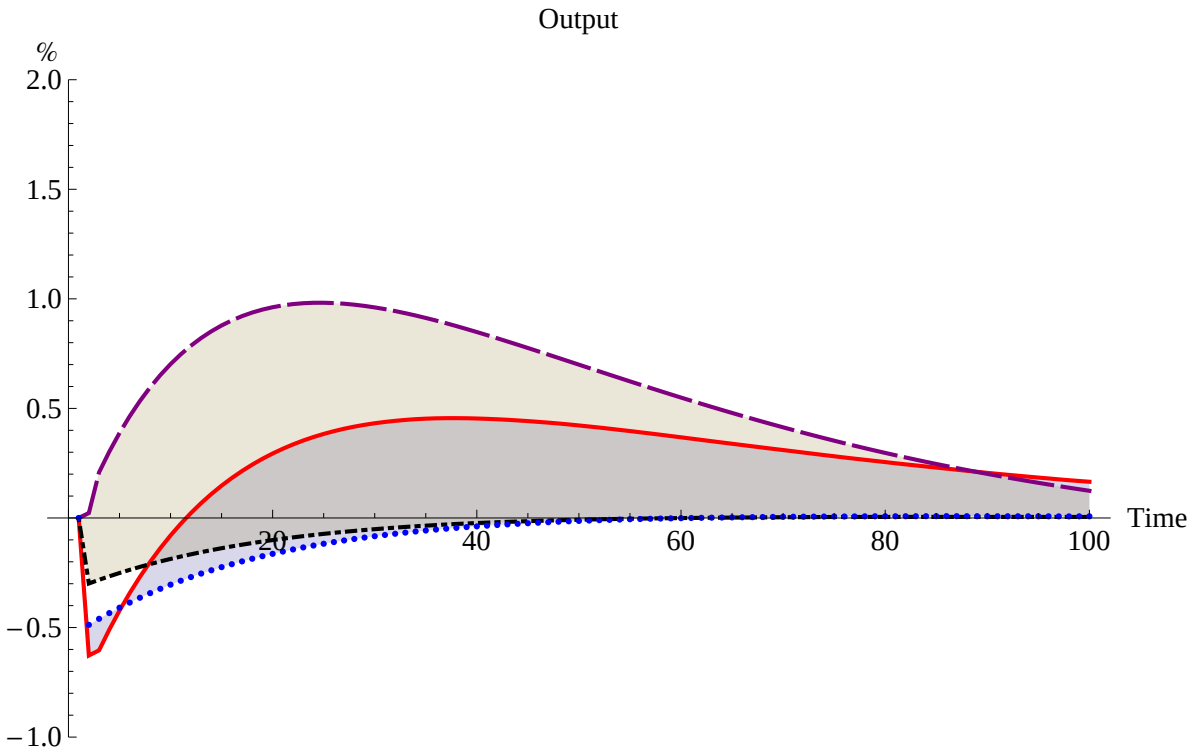
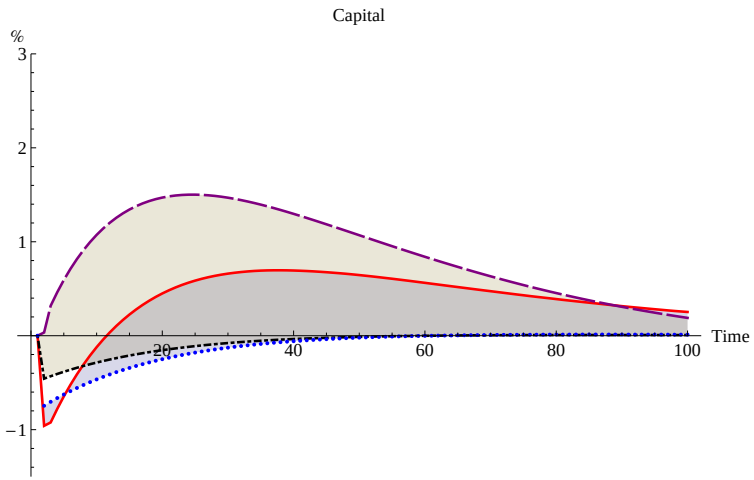


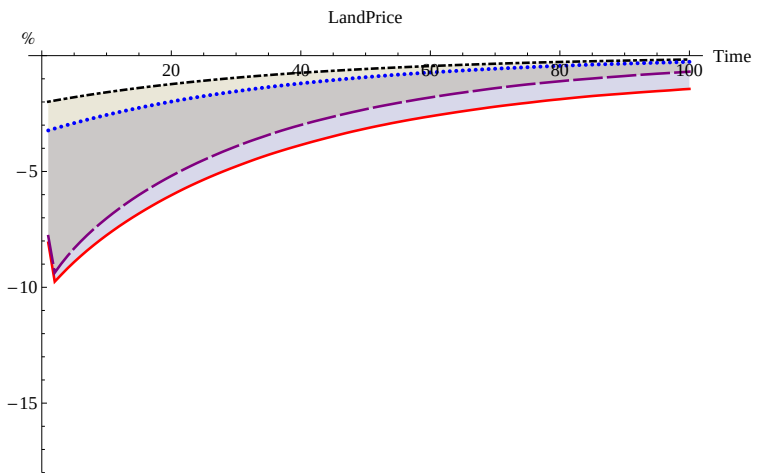
Figure: Responses to a negative leverage shocks for mildly counter-cyclical ($\varepsilon = -0.5\%$) leverage under learning (solid red) and RE (dotted blue) and strongly counter-cyclical $\varepsilon = -1.5\%$) leverage under learning (dashed purple) and RE (dashed-dotted black) given the incorrect beliefs regarding the macro-prudential policy.

Wrong beliefs

- Dynamics driven by the behavior of capital and not land price



(a) Capital following 5% leverage shock.

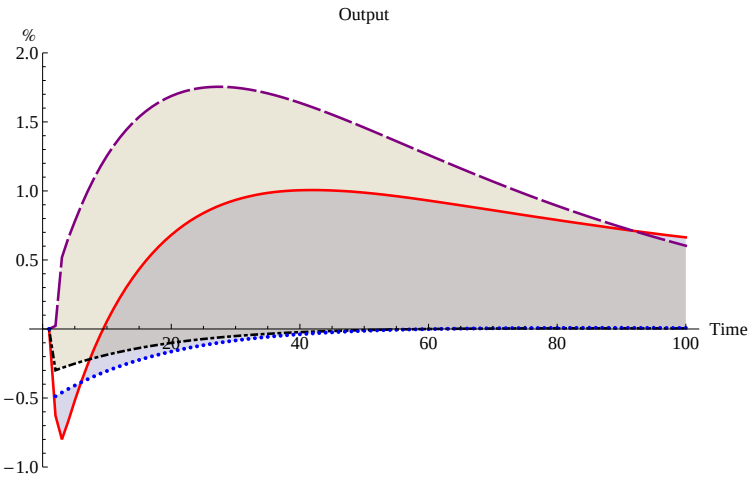


(b) Land price following 5% leverage shock.

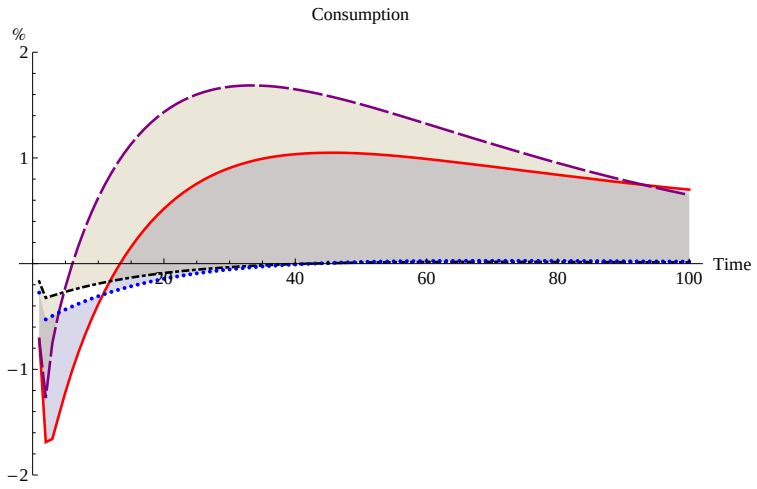
Responses to a negative leverage shocks for mildly counter-cyclical ($\varepsilon = -0.5\%$) leverage under learning (solid red) and RE (dotted blue) and strongly counter-cyclical $\varepsilon = -1.5\%$) leverage under learning (dashed purple) and RE (dashed-dotted black) given the incorrect beliefs regarding the macro-prudential policy.

Confidence

- Reduction of confidence in the policy makes reaction under learning even larger



(a) Output following 5% leverage shock with low initial confidence.



(b) Consumption following 5% leverage shock with low initial confidence.

Responses to a negative leverage shocks for mildly counter-cyclical ($\varepsilon = -0.5\%$) leverage under learning (solid red) and RE (dotted blue) and strongly counter-cyclical $\varepsilon = -1.5\%$) leverage under learning (dashed purple) and RE (dashed-dotted black) given the incorrect beliefs regarding the macro-prudential policy but with less confidence.

Conclusion

- Simple model with adaptive learning
- Learning (for the leverage shocks) can act as amplification mechanism under pro-cyclical leverage
- Counter-cyclical leverage can reduce this amplification significantly...
- ...but only if it is expected.
- Eventual policy change designed to reduce volatility can lead to opposite results
  - here it is showed for macro-prudential policy...
  - but it is more general
- Important message for the design and implementation of policy changes