The dangers of policy experiments
Initial beliefs under adaptive learning

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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: $\pi^*$, 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
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
- 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
A representative agent solves:

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

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.
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

- $\Theta_t$ is exogenous and subject to random shocks

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

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

- Similarly $T_t$ is subject to random shocks

$$T_t = T_{t-1}^{\rho_T} \Psi_t$$
Borrowers’ first-order conditions are

\[ C_t : \quad \Lambda_t = \left[ C_t - \psi \frac{N_t^{1+\chi}}{1+\chi} \right]^{-\sigma} \]

\[ N_t : \quad \psi N_t^{\chi+\alpha+\gamma} = (1 - \alpha - \gamma)AK_t^\alpha L_t^\gamma \]

\[ L_{t+1} : \quad T_t Q_t \Lambda_t = \beta E_t^* [T_{t+1} Q_{t+1} \Lambda_{t+1}] + \beta \gamma E_t^* [\Lambda_{t+1} Y_{t+1}/L_{t+1}] \]
\[ + \Phi_t \tilde{\Theta}_t E_t^* [Q_{t+1}], \]

\[ K_{t+1} : \quad \Lambda_t = \beta E_t^* [\Lambda_{t+1} (\alpha Y_{t+1}/K_{t+1} + 1 - \delta)] \]

\[ B_{t+1} : \quad \Lambda_t = \beta (1 + R) E_t^* [\Lambda_{t+1}] + (1 + R) \Phi_t \]
REE

- Linearized expectational system (in log levels):

\[ X_t = AX_{t-1} + BE_t^*[X_t] + CE_t^*[X_{t+1}] + N + D\xi_t + F\psi_t, \]

\[ X'_{t} \equiv (c_t, q_t, \lambda_t, \phi_t, b_t, k_t, \theta_t, \tau_t), \xi_t \text{ and } \psi_t \text{ are innovations.} \]

- Under REE, \( E_t^* = E_t \) and there exists a unique stationary equilibrium

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

where \( M^{re} \) and \( H^{re} \) solve

\[ M = [I_8 - CM]^{-1}[A + BM], \]

\[ H = [I_8 - CM^{re}]^{-1}[BH + CH + N]. \]
Learning

- Relax RE assumption: $E_t^* \neq E_t$.
- Agents as econometricians:
  - Endow agents with a perception of the equilibrium law of motion (PLM)
    \[ X_t = MX_{t-1} + H + G\xi_t + J\psi_t, \]
  - has the same VAR(1) structure as RE equilibrium, but
    admits $M \neq M^{re}, H \neq H^{re}, G \neq G^{re}, J \neq J^{re}$.
- Agents update their “beliefs” by estimating a VAR(1).
- Agents use PLM to form expectations
  \[ E_\tau X_{\tau+1} = M_{\tau-1}X_\tau + H_{\tau-1} \]
Learning

- Agents as econometricians:
  - Actual low of motion becomes
    \[ [I_8 - CM_{t-1}]X_t = [A + BM_{t-2}]X_{t-1} + [BH_{t-2} + CH_{t-1} + N] + D\xi_t + F\psi_t \]
  - Assume recursive updating of the perceived law of motion
    \[
    \begin{align*}
    \Omega_t &= \Omega_{t-1} + \nu(X_t - \Omega_{t-1}Z_{t-1})Z_{t-1}'R_{t-1}^{-1} \\
    R_t &= R_{t-1} + \nu(Z_{t-1}Z_{t-1}' - R_{t-1}),
    \end{align*}
    \]
    where \( Z_t' = [1, X_t'] \) and \( \Omega = [H\quad M] \)
  - OLS/RLS if \( \nu_t = 1/t \),
  - constant gain if \( \nu_t = \nu \).

- REE: perceived and actual laws of motions coincide.
Agents learn and at the onset of the recession
- the associated matrix in PLM is $M_{2008Q4}$.
- if agents have learned/estimated $\rho_\theta$, matrix $M_{2008Q4}$ reflects that.

Shocks and beliefs (under learning) affects financial constraint.

Given the stochastic process, in 2008Q4 agents’ perception does not match the true process $M_{2008Q4} \neq M^{RE}$.

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 $QL/Y \approx 0.59$

  \[
  \begin{array}{ccccccc}
  \mu & \beta & \delta & \alpha & \gamma & \varepsilon & \nu \\
  0.99 & 0.96\mu & 0.025 & 0.33 & 0.0093 & 0.5 & 0.004 \\
  \end{array}
  \]

- 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 $2.5 \times$ larger,
  - impact on consumption is more than $3 \times$ larger.

- Deleveraging is more severe under learning
  - fall in land price is $3 \times$ 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

Output

Time

%
Impulse responses

![Impulse responses graph](image-url)
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 ($M^{RE}$) and beliefs ($M_{2008Q4}$) use $\varepsilon = -0.5$
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

**Result:**
- Countercyclical leverage dampens responses to financial shocks.

**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)
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 \( M_{2008Q4} \) reflects \( \epsilon > 0 \)

**Figure:** Responses to a negative leverage shocks for mildly counter-cyclical (\( \epsilon = -0.5\% \)) leverage under learning (solid red) and RE (dotted blue) and strongly counter-cyclical \( \epsilon = -1.5\% \) 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.
- 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