Overborrowing, Financial Crises and ‘Macro-prudential’ Policy

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Financial Crises and Macro-Prudential Policies

- Evidence credit booms typically precede financial crises

- Wide consensus on the need to use Macro-Prudential Policy:
  
  Prevent “overborrowing” ex ante to make economy less vulnerable to crises ex post

- ...but yet quantitative models helpful for the optimal design of macro-prudential policy are scarce

  Need models that can generate financial crises and evaluate the role for policy
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Key Questions:

1. How does Macro-Prudential Policy affect:
   - The incidence and the severity of financial crises,
   - The behavior of asset prices (excess returns, volatility),
   - Welfare?

2. What are the features of macro-prudential instruments:
   - How should these policies be implemented along the business cycle
   - Their magnitudes
   - Time consistency?
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Contribution

- Answer these questions using an equilibrium model of business cycles and asset prices with a collateral constraint:
  - Binding constraint triggers Fisherian deflation and deep recessions
    - fire sale externality (e.g. Lorenzoni, 2007)
  - Characterize constrained efficient allocations under commitment and discretion
  - Quantitatively, evaluate outcomes of decentralized equilibrium and time consistent solution
  - Examine “simple tax schemes” & “conditional efficient” outcomes
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Main Findings

- Planner can achieve significant reduction in financial fragility:
  - Probability of financial crises decreases by a factor of 3
  - Asset prices fall 17 ppts less (7% v. 24%)
  - Overall cyclical variability is also lower
  - Mean excess return and Sharpe ratio decrease by factors of 6 and 10

- Planner’s allocations implementable with state-contingent taxes on debt (1% on average and positively corr. with leverage). Simpler tax schemes also deliver significant gains
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Related Literature

- Overborrowing Externalities and Macroprudential Policy:

- Quantitative Models of Macro-Financial Linkages:
Plan of the Talk

1. Analytics of fire-sale externality
2. Quantitative implications
3. Concluding Remarks
Decentralized Competitive Equilibrium

Households solve:

$$\max_{\{c_t, k_{t+1}, b_{t+1}\}_{t \geq 0}} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t u(c_t)$$

s.t. \( c_t + q_t k_{t+1} + \frac{b_{t+1}}{R} = k_t (q_t + z_t) + b_t \)

\( \frac{b_{t+1}}{R} \geq -\kappa q_t \)

\( z_t \) follows a Markov process, \( \kappa < 1 \)

- Non-state contingent bonds only
- Capital is unit fixed supply \( K = 1 \)
- Interest rate is exogenous. We look at equilibrium, where households are generally borrowers and constraint binds occasionally
Excess Returns

\[ E_t[R^k_{t+1}] - R = \frac{\mu_t(1 - \kappa) - \text{Cov}_t(\beta u'(c_{t+1}), R^k_{t+1} - R)}{\beta E_t u'(c_{t+1})} \]
Excess Returns

A tightening of the constraint leads to increase in excess returns

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causin asset prices to fall

\[ q_t = E_t \sum_{j=0}^{\infty} \frac{z_{t+j+1}}{\prod_{i=0}^{j} E_{t+i}R_{t+1+i}^k} \]

tighten the constraint and feeding back to asset prices

⇒ Ex-ante, leverage magnifies Fisherian deflation → systemic risk externality
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\[ \Rightarrow \text{Ex-ante, leverage magnifies Fisherian deflation } \rightarrow \text{systemic risk externality} \]
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Normative Analysis

- Planner chooses borrowing and transfers proceeds of credit market operations
- Land market remains competitive
- Commitment versus Discretion

- Equivalent approach: Ramsey planner choosing debt taxes
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- Land market remains competitive
- Commitment versus Discretion
- Equivalent approach: Ramsey planner choosing debt taxes
Private Choices in Constrained Efficient Equil.

Taking planner’s policies \{b_{t+1}, T_t\}_{t \geq 0} and asset prices as given, households solve:

\[
\max_{\{c_t, k_{t+1}\}_{t \geq 0}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t)
\]

s.t. \quad c_t + q_t k_{t+1} = k_t(q_t + z_t) + T_t

First order condition and key implementability condition:

\[
q_t u'(c_t) = \beta \mathbb{E}_t [u'(c_{t+1})(z_{t+1} + q_{t+1})]
\]
Commitment Case

Planner solves:

$$\max_{\{c_t, q_t, b_{t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

s.t. $$c_t + \frac{b_{t+1}}{R_t} = z_t + b_t$$

$$\frac{b_{t+1}}{R_t} \geq -\kappa q_t$$

$$q_t u'(c_t) = \beta \mathbb{E}_t u'(c_{t+1})(z_{t+1} + q_{t+1})$$
Commitment Case

Planner solves:

\[
\max_{\{c_t, q_t, b_{t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t)
\]

subject to:

\[c_t + \frac{b_{t+1}}{R_t} = z_t + b_t \quad (\lambda_t)\]

\[\frac{b_{t+1}}{R_t} \geq -\kappa q_t \quad (\mu_t)\]

\[q_t u'(c_t) = \beta \mathbb{E}_t u'(c_{t+1})(z_{t+1} + q_{t+1}) \quad (\xi_t)\]
Optimality Conditions

\[ b_{t+1} : \quad \lambda_t = \beta R_t E_t \lambda_{t+1} + \mu_t \quad \forall t \geq 0 \]

\[ c_t : \quad \lambda_t = u'(c_t) - \xi_t q_t u''(c_t) + u''(c_t) \xi_{t-1} (q_t + z_t) \quad \forall t > 0 \]

\[ q_t : \quad \xi_t = \xi_{t-1} + \frac{\mu_t \kappa}{u'(c_t)} \quad \forall t > 0 \]
Optimality Conditions

\[ \begin{align*} 
    b_{t+1} &:: \quad \lambda_t = \beta R_t E_t \lambda_{t+1} + \mu_t \quad \forall t \geq 0 \\
    c_t &:: \quad \lambda_t = u'(c_t) - \xi_t q_t u''(c_t) + u''(c_t) \xi_{t-1}(q_t + z_t) \quad \forall t > 0 \\
    q_t &:: \quad \xi_t = \xi_{t-1} + \frac{\mu_t \kappa}{u'(c_t)} \quad \forall t > 0
\end{align*} \]

Current consumption raises current asset prices
Optimality Conditions

\[ b_{t+1} :: \quad \lambda_t = \beta R_t E_t \lambda_{t+1} + \mu_t \quad \forall t \geq 0 \]

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\[ q_t :: \quad \xi_t = \xi_{t-1} + \frac{\mu_t \kappa}{u'(c_t)} \quad \forall t > 0 \]

But current consumption also lowers previous asset prices

→ Solution is time inconsistent
Optimality Conditions

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Euler Equation for Bonds

Decentralized Equilibrium \( (\mu_t = 0) \)

\[
u'(c_t) = \beta R E_t u'(c_{t+1})\]

\[\xi_{t-1} = 0, \mu_t = 0\]

\[
u'(c_t) = \beta R E_t \left( u'(c_{t+1}) - \frac{\mu_{t+1} \kappa}{u'(c_{t+1})} q_{t+1} u''(c_{t+1}) \right)\]
Euler Equation for Bonds

Decentralized Equilibrium ($\mu_t = 0$)

$$u'(c_t) = \beta R E_t u'(c_{t+1})$$

Positive wedge between social and private marginal benefits from borrowing.

→ Fire sale externality: Borrow less today to avoid sharp drop in asset price tomorrow
\[ \xi_{t-1} > 0, \mu_t = 0 \]

\[
u'(c_t) + \xi_{t-1}(z_t u''(c_t) - \mathbb{E}_t u''(c_{t+1}) z_{t+1}) = \beta R \mathbb{E}_t \left( u'(c_{t+1}) - \frac{\mu_{t+1} \kappa}{u'(c_{t+1})} q_{t+1} u''(c_{t+1}) \right)
\]

Theoretically ambiguous **current wedge** between private and social benefit from borrowing due to effects on **previous constraints**.
\[ \xi_{t-1} > 0, \mu_t = 0 \]

\[
\begin{align*}
&u'(c_t) + \xi_{t-1} (z_t u''(c_t) - \mathbb{E}_t u''(c_{t+1}) z_{t+1}) = \\
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\end{align*}
\]

Theoretically ambiguous current wedge between private and social benefit from borrowing due to effects on previous constraints. Normally, a positive wedge if constraints are expected to bind.
Decentralized Equilibrium \((\mu_t > 0)\)

\[
u'(c_t) = \beta R \mathbb{E}_t u'(c_{t+1}) + \mu_t
\]

\(\xi_{t-1} = 0, \mu_t > 0\)

\[
u'(c_t) - \frac{\mu_t \kappa q_t u''(c_t)}{u'(c_t)} = \beta R \mathbb{E}_t \left( u'(c_{t+1}) - \frac{\mu_{t+1} \kappa}{u'(c_{t+1})} q_{t+1} u''(c_{t+1}) + u''(c_{t+1}) \mu_t z_{t+1} \right) + \mu_t
\]
Decentralized Equilibrium ($\mu_t > 0$)

$$u'(c_t) = \beta R \mathbb{E}_t u'(c_{t+1}) + \mu_t$$

3. $\xi_{t-1} = 0, \mu_t > 0$

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→ Time consistency problem: Promise lower consumption tomorrow to relax constraint today
**Time Consistent Planner’s Problem**

Taking as given future policies $C$, planner solves:

$$V(b, z) = \max_{c, b', q} u(c) + \beta \mathbb{E} V(b', z')$$

subject to

$$c + \frac{b'}{R} = b + z_t \quad (\lambda)$$

$$\frac{b'}{R} \geq -\kappa q \quad (\mu)$$

$$q = \frac{\beta E u'(C(b', z')(Q(b', z') + z'))}{u'(c)} \quad (\xi)$$
Euler Equation Comparison

Under discretion:

\[ u'(c) - \xi_t u''(c_t) q_t = \beta R\mathbb{E}_t \left( u'(c_{t+1}) - \xi_{t+1} u''(c_{t+1}) Q_{t+1} \right) + \]
\[ \beta \mathbb{E}_t \left( u''(c_{t+1}) \mathcal{C}_b(t+1)(Q_{t+1}(t+1) + z_{t+1}) + Q_b(t+1) u'(c_{t+1}) \right) + \mu_t \]

\[ \xi_t = \frac{\kappa \mu_t}{u'(c_t)} \]
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Under commitment

\[ u'(c_t) - \xi_t q_t u''(c_t) + u'(c_t) \xi_{t-1}(q_t + z_t) = \beta R\mathbb{E}_t (u'(c_{t+1}) - \xi_{t+1} q_{t+1} u''(c_{t+1}) + u''(c_{t+1}) \xi_{t}(q_{t+1} + z_{t+1})) + \mu_t \]

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\[ \xi_t = \xi_{t-1} + \frac{\mu_t \kappa}{u'(c_t)} \]
Remarks on Scope for Policy

Two sources of welfare improving policies:

1. Make **future** constraints less binding

   Borrow less today to reduce fire sales in the future

2. Make **current** constraints less binding:

   (a) Lower future consumption raises current asset prices
       → Requires commitment

   (b) Higher consumption raises current asset prices
       → Non-feasible

Remark: Conditional Efficiency $\approx$ Time Consistent Solution
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Remark: Conditional Efficiency ≈ Time Consistent Solution
Quantitative Model

- Introduce firms, labor supply and working capital
- Capital has individual value as collateral
- Model calibrated to industrialized countries
  - Target of long-run moments include a 3 percent crisis probability
- Focus on time consistent solution
Representative Firm-Household Problem

Maximize:

$$E_0 \left[ \sum_{t=0}^{\infty} \beta^t u(c_t - G(n_t^s)) \right]$$

subject to budget constraint

$$q_t k_{t+1} + c_t + \frac{b_{t+1}}{R} = q_t k_t + b_t + w_t n_t^s + [\varepsilon_t F(k_t, n_t^d) - w_t n_t^d]$$

and collateral constraint

$$- \frac{b_{t+1}}{R} + \theta w_t n_t^d \leq \kappa q_t k_{t+1}$$
Law of Motion for Bonds

Current Bond Holdings

Next Period Bond Holdings

Financial Regulator

Decentralized Equilibrium
Law of Motion for Bonds

- Current Bond Holdings
- Next Period Bond Holdings

Financial Regulator
Decentralized Equilibrium
Debt Dynamics: Decentralized Equilibrium

Current Bond Holdings

Next Period Bond Holdings

Decentralized Equilibrium

45 Degree Line

A

Next Period Bond Holdings

Current Bond Holdings

Decentralized Equilibrium

45 Degree Line

A
Debt Dynamics when Bad Shock hits

![Graph showing debt dynamics with current and next period bond holdings.](Image)
Small diff. in debt in normal times...
Leads to large differences in crises
Distribution of Leverage (measured as $b_{t+1} + \theta w_t h_t$)

Overborrowing can also be assessed by comparing the long-run distributions of debt and leverage across the competitive and constrained-efficient equilibria. The fact that the planner accumulates more precautionary savings implies that its ergodic distribution concentrates less probability at higher leverage ratios than in the competitive equilibrium. Figure 3 shows the ergodic distributions of leverage ratios (measured as $b_{t+1} + \theta w_t h_t$) in the two economies.

The maximum leverage ratio in both economies is given by $\kappa$ but notice that the decentralized equilibrium concentrates higher probabilities in higher levels of leverage. Comparing averages across these ergodic distributions, however, mean leverage ratios differ by less than 1 percent. Hence, overborrowing is relatively small again if measured by comparing differences.
Comparison of Financial Crises: Event Analysis

- Use decision rules to simulate DE and SP for 100,000 periods
- Define a crisis event: binding credit constraint and a fall in credit of more than 1 SD
- Isolate five-year event windows centered in financial crisis periods
- Compute median shocks in $t-2$, $t-1$, $t$, $t+1$, $t+2$ and median initial debt level at $t-2$
- Simulate ‘DE’ and ‘SP’ given initial debt level and sequence of shocks
“Fat Tail in Land Returns” (ergodic CDFs of returns)

The tax on debt is listed in Table 2 because it affects the rate at which dividends are discounted when the planner implements the constrained-efficient equilibrium in a competitive economy. Intuitively, the tax represents the additional premium that the social planner imposes so as to equalize the social benefits of investing in bonds and land. The unconditional average of the tax is 1.07 percent, vs. 0.09 when the constraint binds and 1.09 when it does not.

The tax on debt remains positive, albeit small, on average when the collateral constraint binds because the social planner wants to allocate its borrowing ability across bonds and working capital in a way that differs from the competitive equilibrium. If there is a positive probability that the credit constraint will bind again next period, the social planner allocates less debt capacity to bonds and more to working capital. As a result, a tax on debt is
Welfare Analysis

Welfare effects calculated as increase in permanent consumption that renders DE and SP in terms of utility:

\[ E_0 \sum_{t=0}^{\infty} \beta^t u(c_t^{DE} (1 + \gamma) - G(n_t^{DE})) = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t^{SP} - G(n_t^{SP})) \]

- Two sources of welfare effects from the externality:
  - Production efficiency is affected when constraint binds
  - Larger drops in consumption when constraint binds

- 0.05 percentage points on average

- Higher in the run-up to a financial crisis (about 1.5 times higher)
Conclusions

- Fire-sale externalities increase magnitude and incidence of financial crises, mean excess returns, volatility of returns and Sharpe ratios.

- State contingent taxes on debt can implement the constrained efficient allocations. Simple policies are also effective.

- MPP has to adapt to fin. innovation and differences in information/beliefs (Bianchi, Boz & Mendoza (2012)).

- Road ahead: value of commitment.
Optimality Conditions

\[ b_{t+1} :: \quad \lambda_t = \beta R_t E_t \lambda_{t+1} + \mu_t \quad \forall t \geq 0 \]

\[ c_t : \quad \lambda_t = u'(c_t) - \xi_t q_t u''(c_t) + u''(c_t) \xi_{t-1}(q_t + z_t) \quad \forall t > 0 \]

\[ q_t :: \quad \xi_t = \xi_{t-1} + \frac{\mu_t \kappa}{u'(c_t)} \quad \forall t > 0 \]

commitment
Optimality Conditions

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\[ q_t :: \quad \xi_t = \xi_{t-1} + \frac{\mu_t \kappa}{u'(c_t)} \quad \forall t > 0 \]

\( \xi_t \) is a positive non-decreasing sequence
Optimality Conditions

\[ b_{t+1} : \quad \lambda_t = \beta RE_t \lambda_{t+1} + \]
\[ \beta E_t (u''(c_{t+1})C_b(t + 1)(Q_{t+1}(t + 1)) + z_{t+1}) + Q_b(t + 1)u'(c_{t+1}) + \mu_t \]

\[ c_t : \quad \lambda_t = u'(c_t) - \xi_t u''(c_t)q_t \]

\[ q_t : \quad \kappa \mu_t = \xi_t u'(c) \]
## Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source / target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rate</td>
<td>$R - 1 = 0.028$</td>
<td>U.S. data</td>
</tr>
<tr>
<td>Risk aversion</td>
<td>$\sigma = 2$</td>
<td>Standard DSGE value</td>
</tr>
<tr>
<td>Share of labor</td>
<td>$\alpha_n = 0.64$</td>
<td>U.S. data</td>
</tr>
<tr>
<td>Labor disutility coefficient</td>
<td>$\chi = 0.64$</td>
<td>Normalization</td>
</tr>
<tr>
<td>Frisch elasticity parameter</td>
<td>$\omega = 1$</td>
<td>Kimball and Shapiro (2008)</td>
</tr>
<tr>
<td>Supply of land</td>
<td>$\bar{K} = 1$</td>
<td>Normalization</td>
</tr>
<tr>
<td>Working capital coefficient</td>
<td>$\theta = 0.14$</td>
<td>Working Capital-GDP = 9%</td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta = 0.96$</td>
<td>Debt-GDP ratio = 38%</td>
</tr>
<tr>
<td>Collateral coefficient</td>
<td>$\kappa = 0.36$</td>
<td>Frequency of Crisis = 3%</td>
</tr>
<tr>
<td>Share of land</td>
<td>$\alpha_K = 0.05$</td>
<td>Housing-GDP ratio = 1.35</td>
</tr>
<tr>
<td>TFP process</td>
<td>$\sigma_\varepsilon = 0.014, \rho_\varepsilon = 0.53$</td>
<td>Std. dev. and autoc. of U.S. GDP</td>
</tr>
</tbody>
</table>
Conditional Efficiency

\[ V(B, z) = \max_{B', c} \left[ u(c) + \beta E_{z'|z} V(B', z') \right] \]

\[ c + \frac{B'}{R} = z + B \]

\[ -\frac{B'}{R} \leq \kappa q(B, z) \]

Taking as given \( q(B, z) = q^{DE}(B, z) \),