Macroprudential Policy in Fisherian Models of Credit Booms & Crises[1]

[1]Based on "Optimal Time-Consistent Macroprudential Policy" co-authored with Javier Bianchi, Univ. of Wisconsin

Financial Crises and Macroprudential Policies

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- Wide consensus on MPP(Borio, EMs, Bernanke): Reduce risk of systemic financial crises by managing credit expansions in good times
- But quantitative MPP models face serious challenges: (1) capture nonlinear crises dynamics and prudential mechanisms; (2) evaluate effectiveness (optimal or suboptimal); (3) address time inconsistency

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- Examine optimal MPP of a regulator unable to commit
- Study time-inconsistency problem of financial regulator
- Compare with simple (non-state-contingent) policies

Main Theoretical Findings

- Constrained-efficient allocations can be decentralized with state contingent MP tax on borrowing
- Forward looking asset pricing introduces time-inconsistency issues in financial regulation
- Under commitment, regulator seeks to prop up current asset prices by distorting future path of consumption
- Under discretion, ability to affect asset prices is limited to altering current marginal utility and state variables of future regulators

Main Quantitative Findings

- Optimal time-consistent MPP achieves **significant reduction in financial fragility**:
  - Probability of crises falls from 3 % to 0.3%
  - Asset Prices fall 25 ppts less (5% v. 30%)
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- Tax on debt averages 1% and positively corr. with leverage
- **Simpler taxes** also deliver gains but are harmful during crises

Related Literature

- **Pecuniary Externalities and Macroprudential Policy**: Caballero-Krishnamurthy (2001), Lorenzoni (2008), Bianchi (2011), Jeanne-Korinek (2011), Benigno et al. (2010), Stein (2012), Kashyap et al. (2012)
- **Quantitative Models of Macro-Financial Linkages:**
  - **Financial Accelerator Models**: Bernanke-Gertler-Gilchrist (1999), Kiyotaki-Moore (1997), Jermann-Quadrini (2012), Gertler-Kiyotaki (2010)...
  - **Non-Linear (Systemic Risk) Models**: Mendoza (2010), Bianchi (2012), He-Krishnamurthy (2012), Brunnermeier-Sannikov (2011)...
- **Markov Perfect Equilibrium:** Klein-Krusell-Rios-Rull (2008), Judd (2004), Krusell-Smith (2003)...

Outline

1. Analytics of Pecuniary Externality
2. Model for Quantitative Analysis
3. Quantitative Implications
4. Concluding Remarks

Environment

Households solve:

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

$$\begin{aligned} s.t. \quad c_t + q_t k_{t+1} + \frac{b_{t+1}}{R} &= k_t(q_t + z_t) + b_t \\ \frac{b_{t+1}}{R} &\geq -\kappa q_t k_t \end{aligned}$$

z_t follows a Markov process

- One-period non-state contingent bonds
- Aggregate capital is in unit fixed supply $K = 1$
- Exogenous interest rate with $\beta R < 1$

Microfoundation of Credit Constraint

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▸ Eq. Definition

Excess Returns

Binding constraint increases excess returns

$$\mathbb{E}_t[R^k_{t+1}] - R = \frac{\mu_t - Cov_t(\beta u'(c_{t+1}), R^k_{t+1} - R)}{\beta \mathbb{E}_t u'(c_{t+1})}$$

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causing asset prices to fall

$$q_t = \mathbb{E}_t \sum_{j=0}^{\infty} \frac{z_{t+j+1}}{\prod_{i=0}^{j} \mathbb{E}_{t+i} R^k_{t+1+i}}$$

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.... but agents do not internalize effects of ex-ante borrowing decisions on q_t ex post $\Rightarrow$ **pecuniary (systemic or fire-sale) externality**

Normative Analysis

- Constrained efficient regulator (planner) chooses debt and transfers borrowed resources facing the same credit constraint.
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- Households choose consumption and asset holdings.
- Asset market remains competitive
- Equivalent approach: Ramsey planner choosing debt taxes

Private Choices in Constrained-Efficient Eq.

Taking planner's policies for debt and transfers $\{b_{t+1}, T_t\}_{t\geq 0}$ and asset prices as given, **households** solve:

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

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First-order condition and key implementability condition:

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

Time-Consistent Regulator's Problem

Taking as given future policies $\mathcal{C}, \mathcal{B}$ and implied price $\mathcal{Q}$, planner solves:

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

subject to

$$\begin{aligned} c + \frac{b'}{R} &= b + z && (\lambda) \\ \frac{b'}{R} &\geq -\kappa q && (\mu) \end{aligned}$$

$$q = \frac{\beta \mathbb{E} u'(\mathcal{C}(b',z'))(\mathcal{Q}(b',z') + z')}{u'(c)} \qquad (\xi)$$

Recursive Constrained Efficient Equilibrium

The recursive **constrained efficient equilibrium** is a collection of functions $\{\mathcal{B}, \mathcal{C}, k, c, \mathcal{Q}, \mathcal{V}\} : R^2 \rightarrow R$ such that:

1. The regulator's current plans are optimal: $\mathcal{V}(b, z), b'(b, z), c(b, z)$ and $q(b, z)$ solve the Bellman equation given $\mathcal{B}(b, z), \mathcal{C}(b, z), \mathcal{Q}(b, z)$.

2. The regulator's plans are time consistent (Markov stationarity): $b'(b, z) = \mathcal{B}(b, z), c(b, z) = \mathcal{C}(b, z), q(b, z) = \mathcal{Q}(b, z)$.

Planner's first-order conditions

$$c_t: \quad \lambda_t = u'(c_t) - \underbrace{\xi_t u''(c_t) q_t}_{\text{Extra Benefits from } c_t}$$

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$$b_{t+1} : \quad \lambda_t = \beta R \mathbb{E}_t \lambda_{t+1} +$$

$$\underbrace{\xi_t \beta \mathbb{E}_t \left(u''(c_{t+1}) \mathcal{C}_b(t+1) (\mathcal{Q}_{t+1}(t+1)) + z_{t+1}) + \mathcal{Q}_b(t+1) u'(c_{t+1}) \right)}_{\text{Effects of Future Policies on Current Asset Prices}} + \mu_t$$

▸ Planner's Problem

Overborrowing and Pecuniary Externality

Bonds Euler eq. in unregulated decentralized equilibrium when $\mu_t = 0$:

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

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Bonds Euler eq. in constrained-efficient equilibrium $\mu_t = 0$:

$$u'(c_t) \quad = \quad \beta R \mathbb{E}_t \left\{ u'(c_{t+1}) - \kappa \mu_{t+1} \, q_{t+1} \frac{u''(c_{t+1})}{u'(c_{t+1})} \right\}$$

Comparison with commitment

Optimality conditions if the regulator can commit:

$$b_{t+1} :: \quad \lambda_t = \beta R_t \mathbb{E}_t \lambda_{t+1} + \mu_t \qquad \forall t \geq 0$$

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

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

Current consumption raises current asset prices

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→ **Solution is time inconsistent**

Decentralization with Tax on Debt

- In a regulated decentralized equilibrium, the regulator imposes a tax on debt (or bond purchases)
- Budget constraint with debt tax:

$$q_t k_{t+1} + c_t + \frac{b_{t+1}}{R(1+\tau_t)} = k_t(z_t + q_t) + b_t + T_t$$

- Agents' Euler equation for bonds:

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

- An optimal tax schedule matches Euler eq. of the regulator & implements same allocations

Optimal Debt Taxes

Proposition: The time-consistent constrained-efficient equilibrium can be decentralized with state-contingent debt taxes τ_t with revenue rebated as a lump-sum transfer.

$$\tau_t = \frac{R\mathbb{E}_t\left\{-\xi_{t+1}u''(\mathcal{C}(b_{t+1}, z_{t+1}))\mathcal{Q}(b_{t+1}, z_{t+1}) + \xi_t\Omega_{t+1} + \xi_t u''(c_t)q_t\right\}}{\mathbb{E}_t u'(\mathcal{C}(b_{t+1}, z_{t+1}))}$$

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- The tax has a MP component (i.e. when $\mu_t = 0$ but $\mathbb{E}_t[\mu_{t+1}] > 0$):

$$\tau_t^{MP} = \frac{-\mathbb{E}_t \frac{\kappa \mu_{t+1}}{u'(\mathcal{C}(b_{t+1}, z_{t+1}))} u''(\mathcal{C}(b_{t+1}, z_{t+1}))\mathcal{Q}(b_{t+1}, z_{t+1})}{\mathbb{E}_t u'(\mathcal{C}(b_{t+1}, z_{t+1}))}$$

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- Equivalent policies: capital req., LTV ratios (Bianchi, 2011)

Quantitative Analysis

- Introduce firms, labor supply, imported inputs and working capital
- Capital has individual value as collateral
- TFP, interest rate and financial shocks
- Calibration to industrialized countries

Representative Firm-Household Problem

Maximize:

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t u(c_t - G(n_t))\right]$$

subject to budget constraint

$$q_t k_{t+1} + c_t + \frac{b_{t+1}}{R}_t = q_t k_t + b_t + [z_t F(k_t, m_t, h_t) - p_m m_t]$$

and collateral constraint

$$-\frac{b_{t+1}}{R} + \theta p_m m_t \leq \kappa_t q_t k_t$$

Market Clearing: $h_t = n_t, k_t = 1$

Calibration Strategy

- Industrialized economies for post-financial globalization period (1984:Q1–2010:Q2):
- Preferences and production parameters set independently to match standard targets
- TFP and interest rates estimated as a VAR(1)
- Financial shocks are assumed to be independent and follow a two-state Markov chain $\left\{\kappa^L, \kappa^H\right\}$ with transition matrix $\mathcal{P}$
- $\mathcal{P}$ calibrated to match frequency and duration of financial crises (crisis defined as a fall in credit of more than 2SD)

Functional Forms

$$u(c - G(n)) = \frac{\left(c - \chi \frac{n^{1+\omega}}{1+\omega}\right)^{1-\sigma} - 1}{1-\sigma} \quad \omega > 0, \sigma > 1$$

$$F(k, h, m) = zk^{\alpha_K} m^{\alpha_m} h^{\alpha_h}, \qquad \alpha_K, \alpha_m, \alpha_h \geq 0$$

Calibration

Description	Value	Source / target
Risk aversion	$\sigma = 1.5$	Standard value
Discount factor	$\beta = 0.96$	Standard value
Share of imported inputs	$\alpha_v = 0.124$	Cross-country data from Golberg and Campa (2010)
Share of labor	$\alpha_n = 0.56$	0.64 cross-country data from Stockman and Tesar (1995)
Share of assets	$\alpha_k = 0.05$	2007 U.S. housing stock/GDP =1.3
Labor disutility coefficient	$\chi = 0.56$	Normalizatition for average $h = 1$
Frisch elasticity parameter	$\omega = 1$	Kimball and Shapiro (2008)
Working capital coefficient	$\theta = 0.5$	2007 U.S. firms' $M1/GDP = 0.1$
Financial shock		
	$\kappa^L = 0.3$	Average leverage = 30%
	$P_{HH} = 0.9$	10-year mean duration of κ^H (crisis prob.=0.03)
	$P_{LL} = 0.1$	Prob. of κ^L=0.1 (3-year crisis duration)

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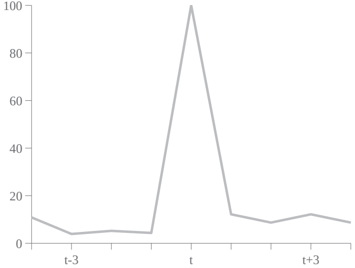
Quantitative Results

1. Severity of Financial Crises
2. Bond Policy Functions
3. Asset Pricing
4. Policies
5. Welfare

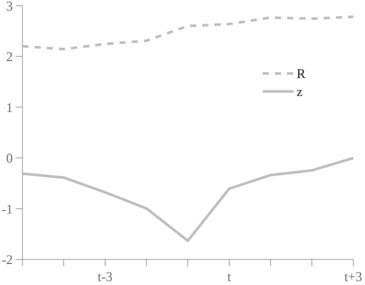
Event Analysis

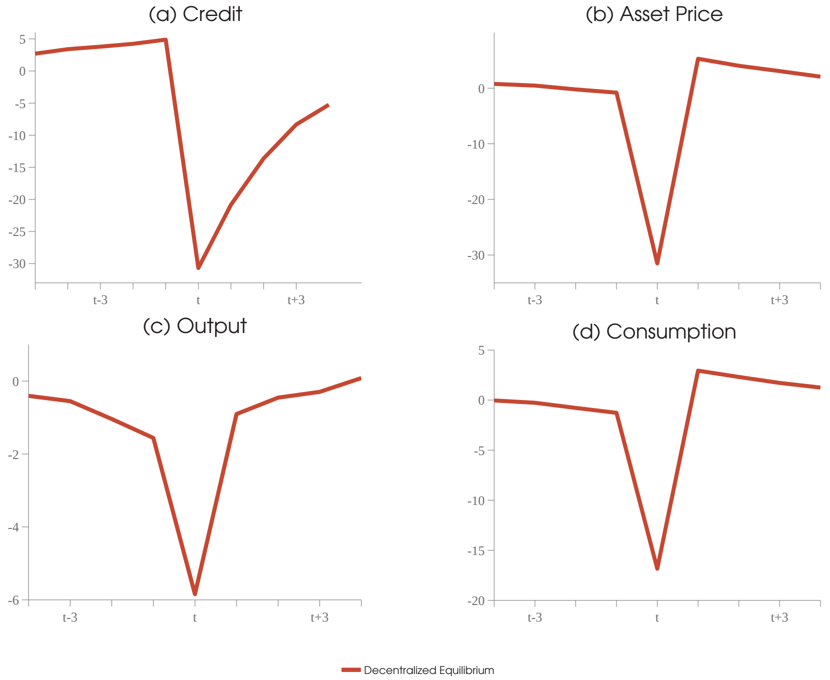
1. Simulate decentralized equilibrium for long-number of periods
2. Isolate 7-year event windows around crises
3. Compute mean values of all macro-variables and shocks
4. Counterfactual policy experiment: feed shocks and initial conditions to constrained-efficient equilibrium

(e) Fraction of Simulations with $\kappa=\kappa^L$



TFP and Interest Rate Shocks




(a) Credit
5
0
-5
-10
-15
-20
-25
-30
t-3
t
t+3
(b) Asset Price
0
-10
-20
-30
t-3
t
t+3
(c) Output
0
-2
-4
-6
t-3
t
t+3
(d) Consumption
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t
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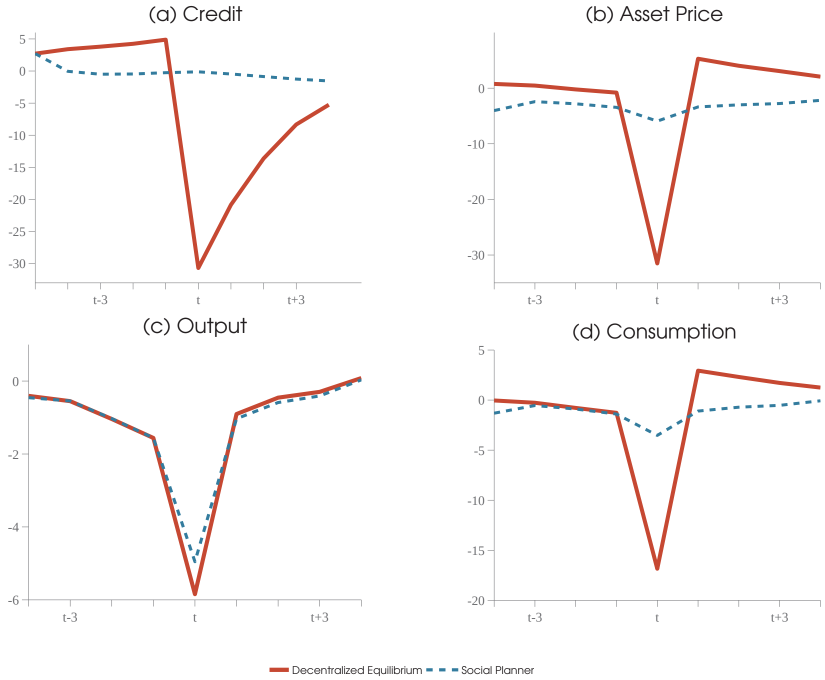
Decentralized Equilibrium



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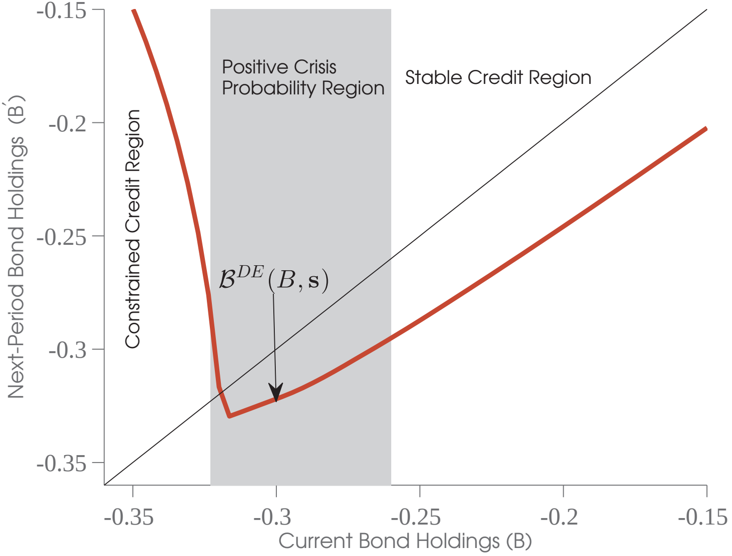
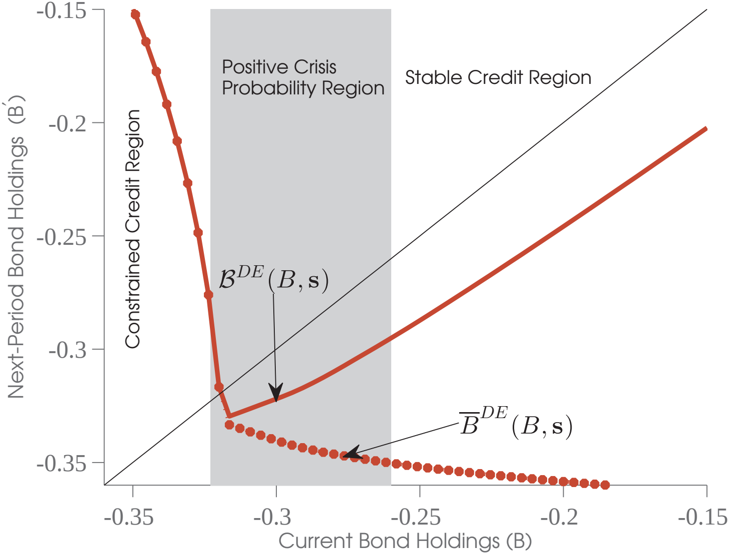
Decentralized Equilibrium
Social Planner

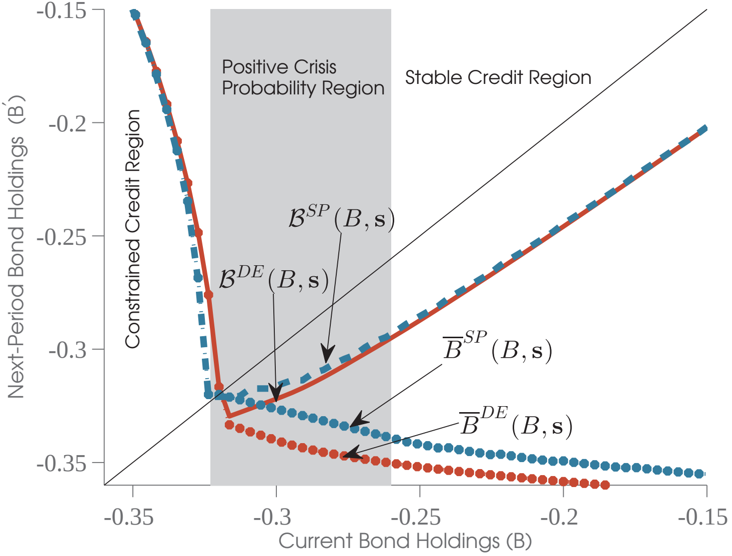
DE Bond Policy Function



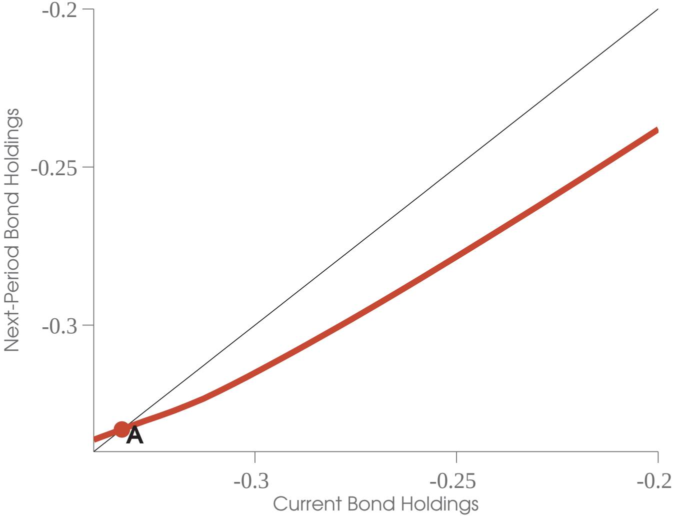
DE Bond Policy Function & Credit Limit



Comparing DE and SP

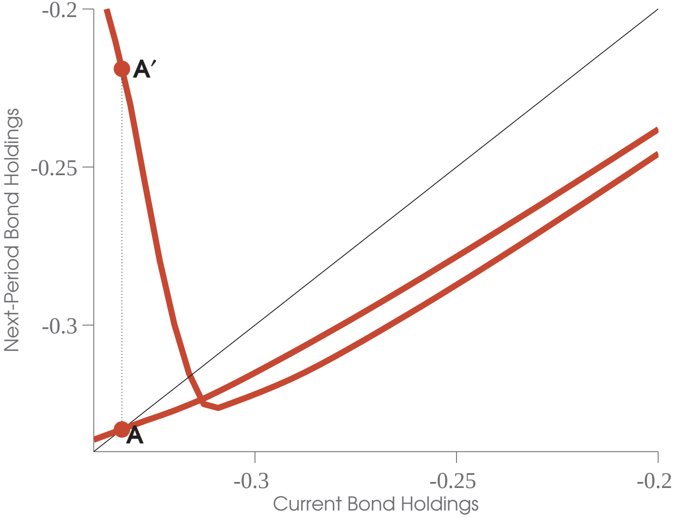


Financial Amplification in DE



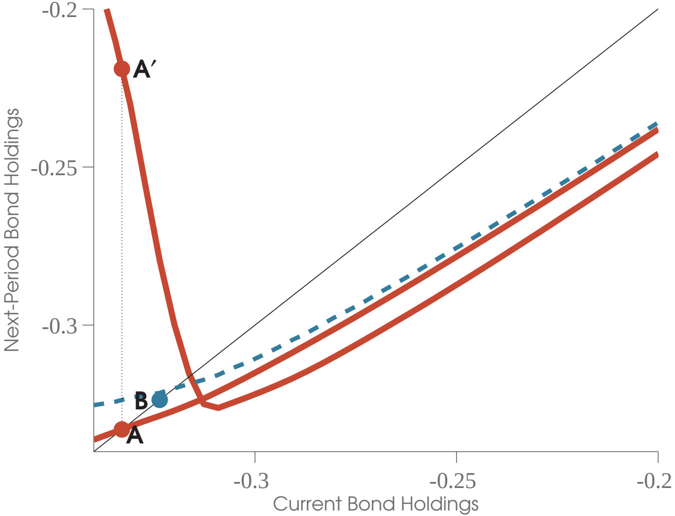
Stationary bond choice at t with “good” shock

Financial Amplification in DE Cont.



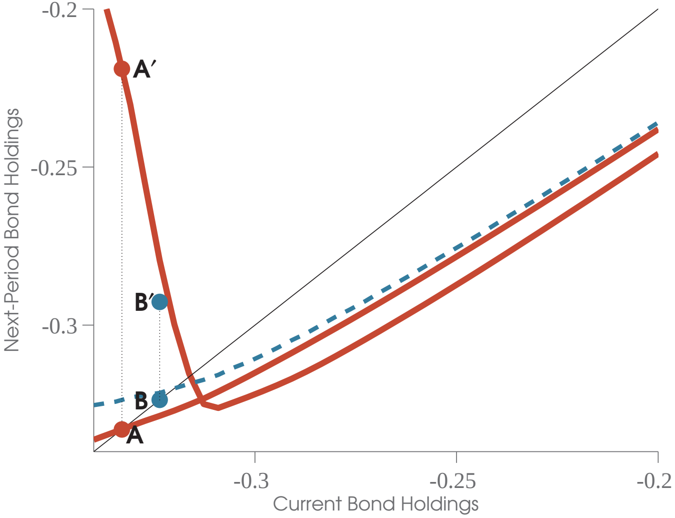
Response to a bad shock at $t+1$

Financial Amplification for the Planner



SP's bond choice at t for same initial condition

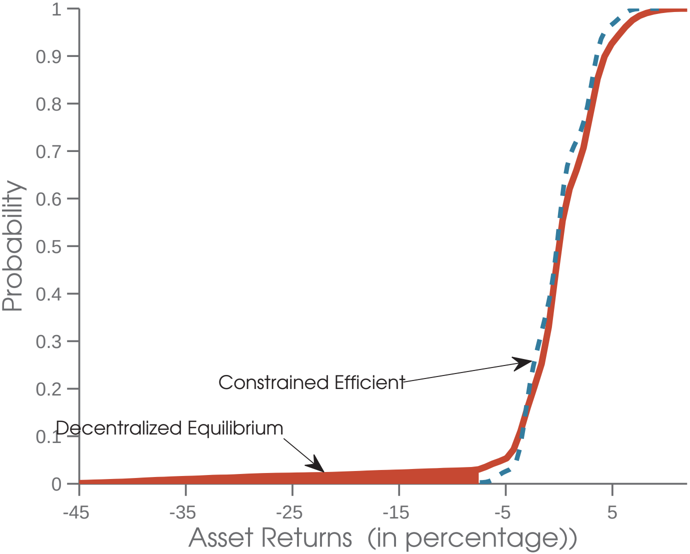
Financial Amplification for the Planner Cont.



SP's response to SAME bad shock at $t+1$

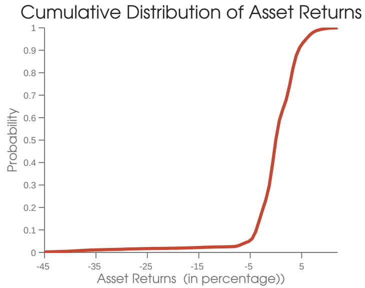
Asset Pricing

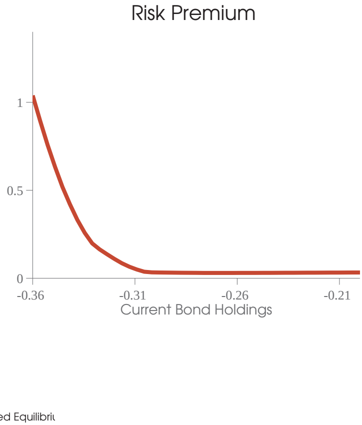
Distribution of Asset Returns



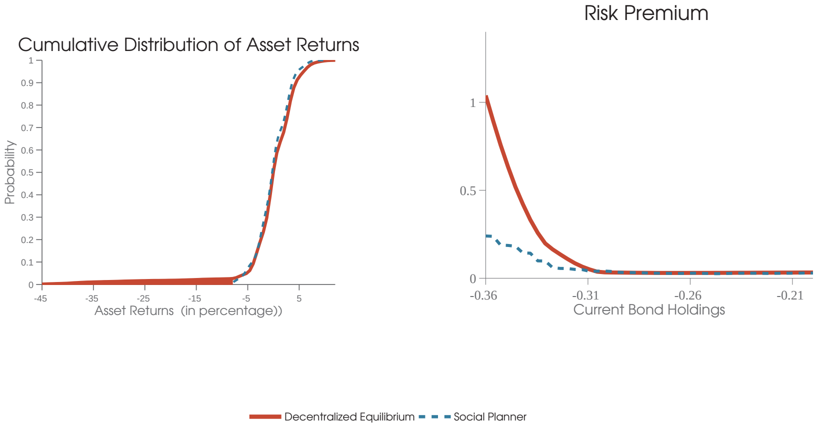
Ergodic Cumulative Distribution of Realized Asset Returns

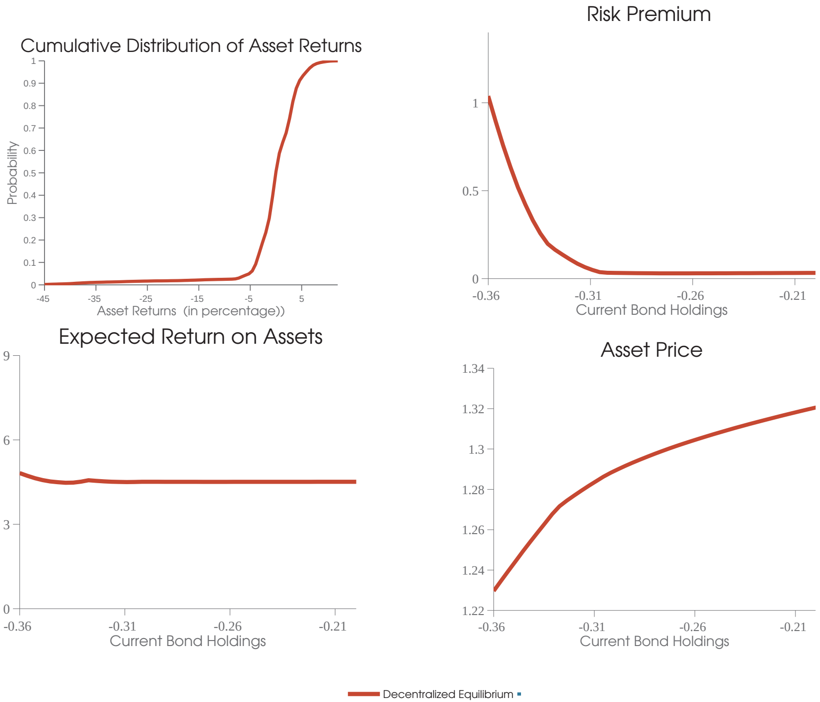
Risk Premia in Good States

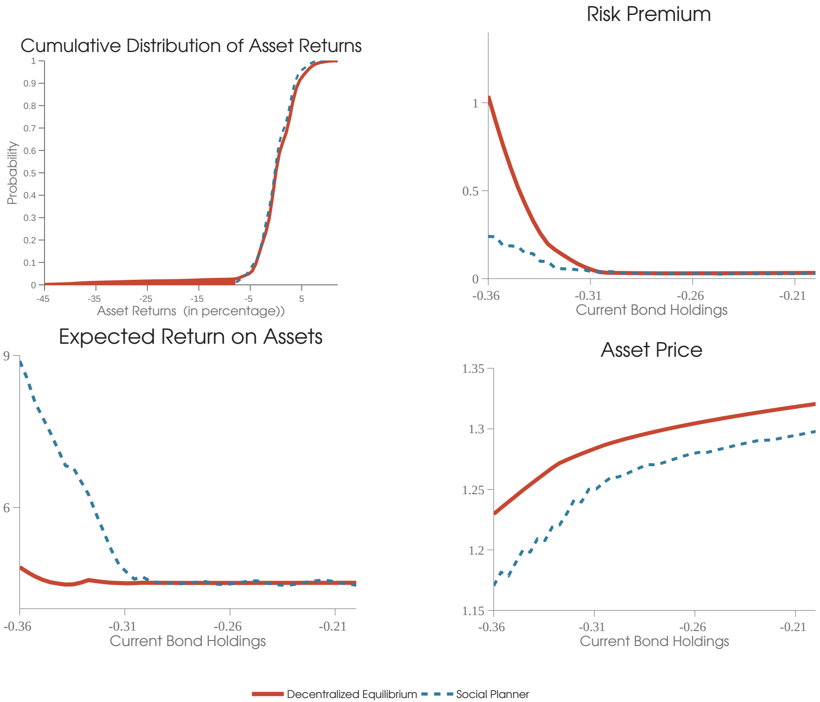




Risk Premia in Good States



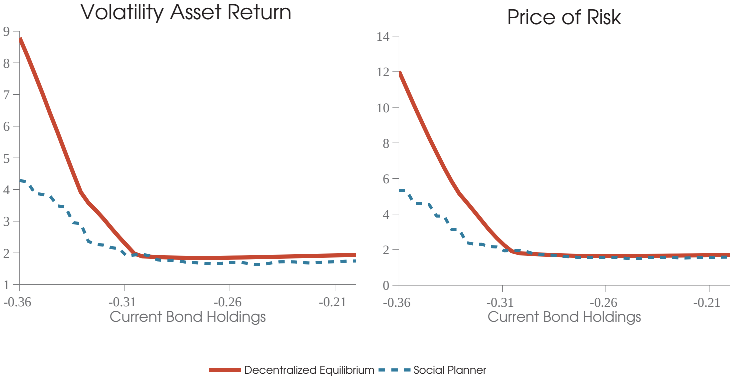

Cumulative Distribution of Asset Returns
Probability
Asset Returns (in percentage))
Risk Premium
Current Bond Holdings
Expected Return on Assets
Current Bond Holdings
Asset Price
Current Bond Holdings
Decentralized Equilibrium



Cumulative Distribution of Asset Returns
Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-45
-35
-25
-15
-5
5
Asset Returns (in percentage))
Risk Premium
1
0.5
0
-0.36
-0.31
-0.26
-0.21
Current Bond Holdings
Expected Return on Assets
9
6
-0.36
-0.31
-0.26
-0.21
Current Bond Holdings
Asset Price
1.35
1.3
1.25
1.2
1.15
-0.36
-0.31
-0.26
-0.21
Current Bond Holdings
Decentralized Equilibrium
Social Planner

Volatility of Returns & Market Price of Risk in Good States

Volatility of Returns & Market Price of Risk in Good States



Asset Pricing Statistics

	$\mathbb{E}_t R^k_{t+1}$	$R+\tau$	Equity Premium	Collateral Current	Expected	Risk Premium	Price of Risk	$\sigma_t(R^q_{t+1})$	SR_t
Decentralized Equilibrium									
Mean	4.3	2.8	1.5	1.3	-0.2	0.4	5.8	4.7	0.3
Unconst.	2.9	2.8	0.1	0.0	-0.25	0.37	5.9	4.7	0.03
Social Planner									
Mean	3.9	3.4	0.5	0.6	-0.17	0.07	2.6	2.6	0.2
Unconst.	3.9	4.0	-0.09	0.0	-0.15	0.07	2.6	2.6	-0.03

Asset Pricing Statistics

	$\mathbb{E}_t R^k_{t+1}$	$R+\tau$	Equity Premium	Collateral Current	Collateral Expected	Risk Premium	Price of Risk	$\sigma_t(R^q_{t+1})$	SR_t
Decentralized Equilibrium									
Mean	4.3	2.8	1.5	1.3	-0.2	0.4	5.8	4.7	0.3
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Mean	3.9	3.4	0.5	0.6	-0.17	0.07	2.6	2.6	0.2
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Asset Pricing Statistics

	$\mathbb{E}_t R^k_{t+1}$	$R+\tau$	Equity Premium	Collateral Current	Expected	Risk Premium	Price of Risk	$\sigma_t(R^q_{t+1})$	SR_t
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Mean	4.3	2.8	1.5	1.3	-0.2	0.4	5.8	4.7	0.3
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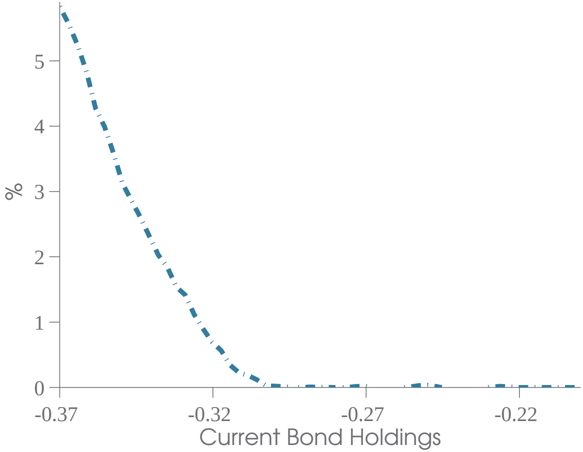
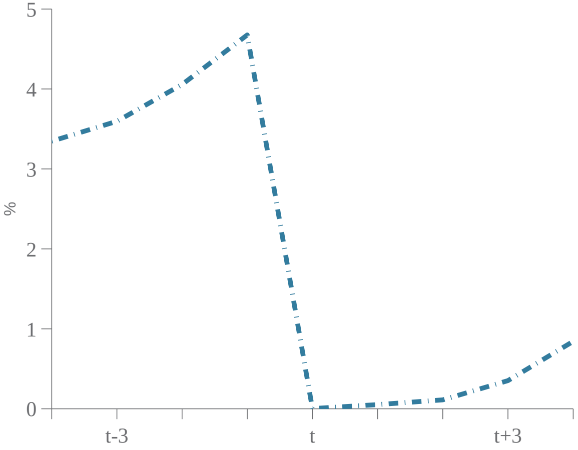
Unconst.	3.9	4.0	-0.09	0.0	-0.15	0.07	2.6	2.6	-0.03

Optimal Tax Schedule in Good States



Optimal Tax Schedule in the Run-up to Crises



Welfare Analysis

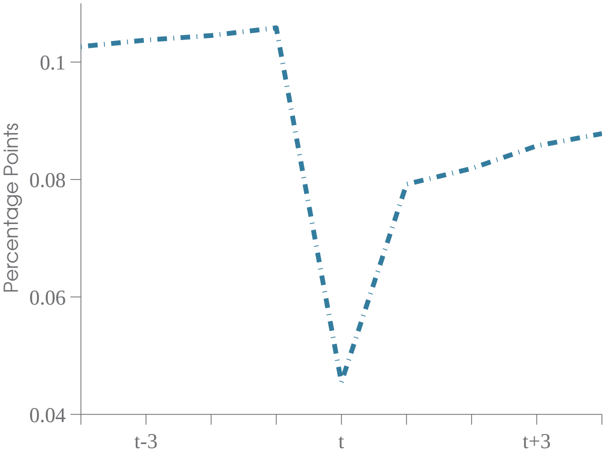
Welfare Calculation

Welfare gains from switching to the constrained-efficient equilibrium are computed as the value of γ such that:

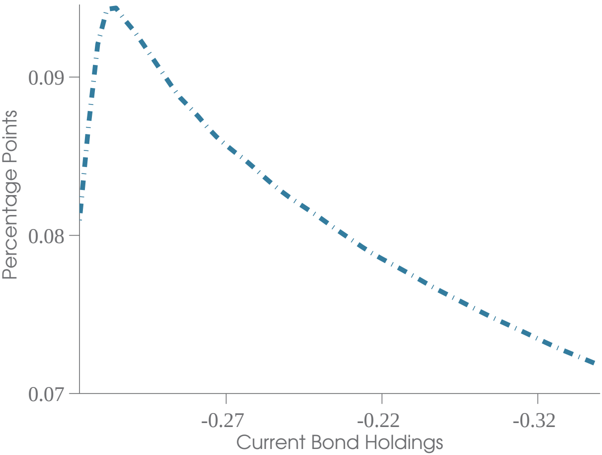
$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^{DE}(1+\gamma_0) - G(n_t^{DE})) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^{SP} - G(n_t^{SP}))$$

for every initial state

Welfare Gains of MPP in the Run-up to Crises

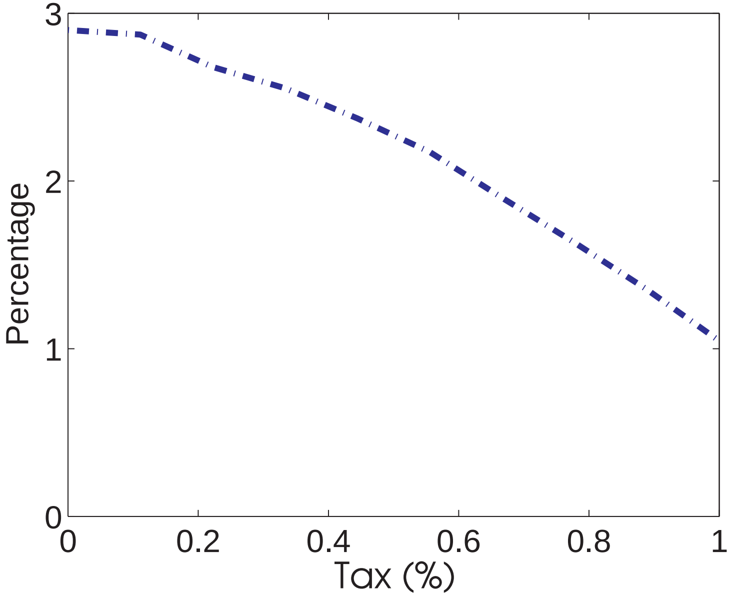


Schedule of Welfare Gains in Good States

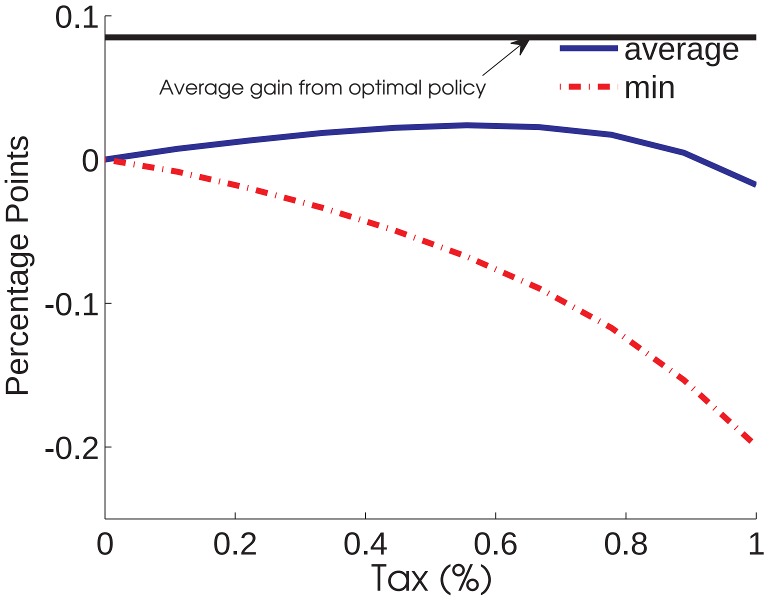


Time Invariant Taxes

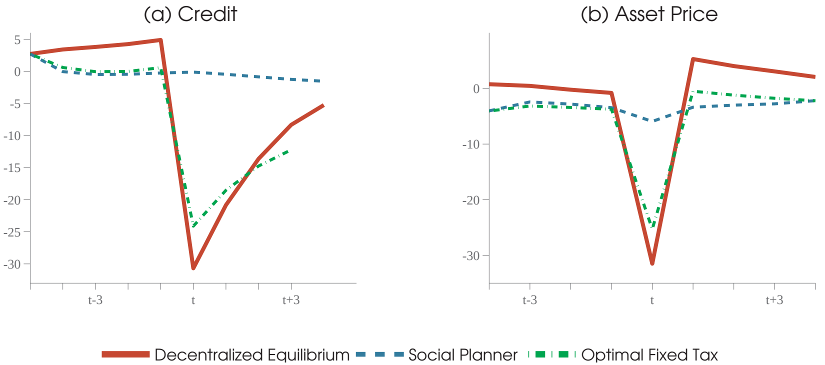
Effects of Constant Taxes on Crisis Probability



Welfare Effects of Constant Taxes



Effects of “Optimal” Constant Tax on Crises



Conclusions

- State-contingent debt taxes can decentralize the constrained efficient, time-consistent equilibrium.
- Optimal MPP can significantly reduce the magnitude and incidence of financial crises, and reduce also risk premia and Sharpe ratios
- Constant taxes are less effective and can be welfare reducing (harmful during crises)
- MPP also faces other implementation challenges and has to adapt to fin. innovation (Bianchi, Boz & Mendoza (2012))

Recursive Competitive Equilibrium

A RCE is defined by $q(B,z)$, a law of motion $\mathcal{B}$ and policy functions:

1. $\left\{V, \hat{b}', \hat{k}', \hat{c}\right\}$ solve:

$$V(b,k,B,z) = \max_{b',k',c} u(c) + \beta \mathbb{E}_{z'|z} V(b',k',B',z')$$

$$\begin{aligned} s.t. \quad & q(B,z)k' + c + \frac{b'}{R} = k\left(q(B,z) + z\right) + b \\ & -\frac{b'}{R} \leq \kappa q(B,z) \end{aligned}$$

   with $B' = \mathcal{B}(B,z)$

2. Rational Expectations: $\mathcal{B}(B,z) = \hat{b}(B,1,B,z)$.
3. Market for land clears $\hat{k}'(B,1,B,z) = 1$

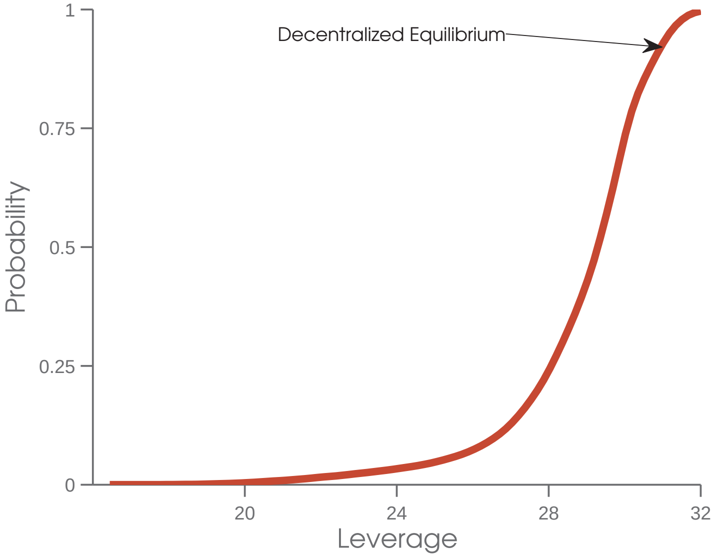
▸ Back

Microfoundation for Collateral Constraint

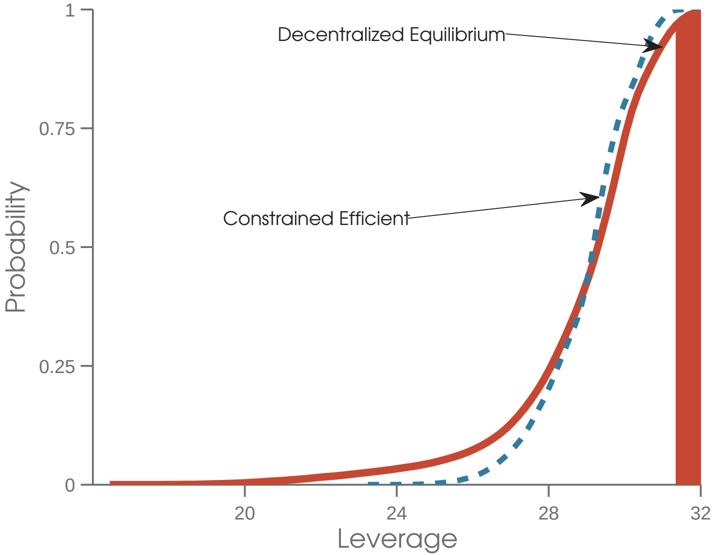
- Opportunity to default arises upon new issuances
  - Hiding assets and future income takes time
- Households enter period with outstanding debt and repay
- Households issue new debt
- Can immediately default on that debt
- Lose a fraction $(1-\kappa)$ of capital holdings
- and can immediately raise new debt

$\Rightarrow$ Collateral constraint $-\frac{b'}{R} \leq \kappa q k$

model2



Cumulative Ergodic Distribution of Leverage $\left(\frac{-b_{t+1}+\theta p_m m_t}{q_t}\right)$



Cumulative Ergodic Distribution of Leverage $\left(\frac{-b_{t+1}+\theta p_m m_t}{q_t}\right)$

Commitment Versus Discretion

If constraint not initially binding, $\mu_t = 0$

$$\begin{aligned} u'(c_t) &= \beta \mathbb{E}_t \left\{ R u'(c_{t+1}) - \kappa \mu_{t+1} q_{t+1} \frac{u''(c_{t+1})}{u'(c_{t+1})} \right\} \\ & \quad + \xi_{t-1} \mathbb{E}_t \left(\beta R u''(c_{t+1}) z_{t+1} - u''(c_t) z_t \right) \end{aligned}$$

Discretion

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

Under **commitment**, planner weights effects of consumption on tightness of previous constraints Given consumption, a positive shock today, reduces incentives to consume today

Stochastic Processes

TFP and interest rate shocks:

$$\boldsymbol{\rho} = \begin{bmatrix} 0.755972 & -0.030037 \\ -0.074327 & 0.743032 \end{bmatrix},$$

$$\mathbf{Cov} = \begin{bmatrix} 0.0000580 & -0.0000107 \\ -0.0000107 & 0.0001439 \end{bmatrix}.$$

$$P = \begin{bmatrix} 0.9 & 0.1 \\ 0.85 & 0.15 \end{bmatrix},$$

calibration