Managing Credit Booms and Busts
A Pigouvian Taxation Approach

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Key Question

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How should policymakers respond to booms and busts in credit markets and asset markets?

Key Assumptions

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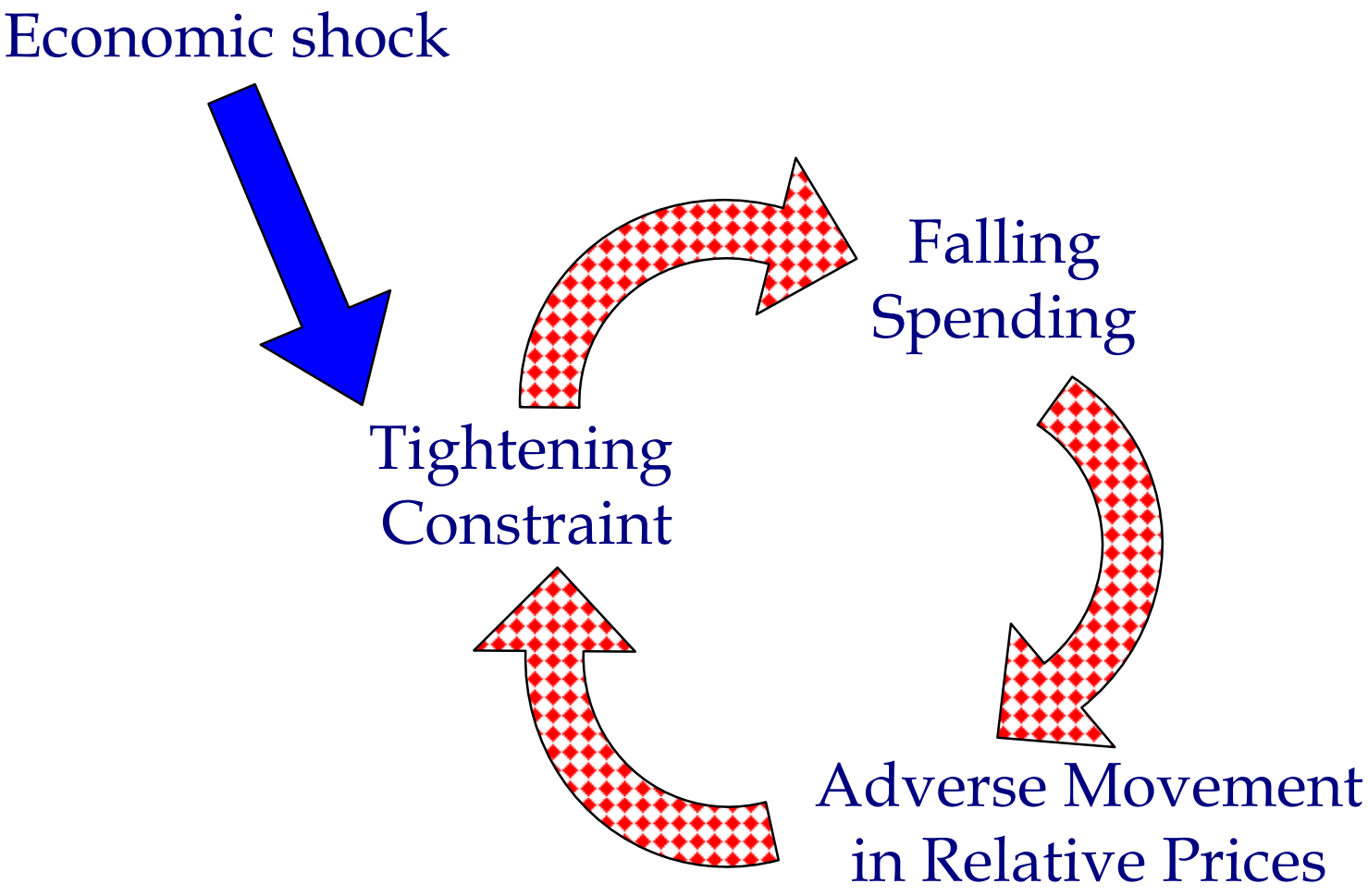
Financial markets are imperfect:

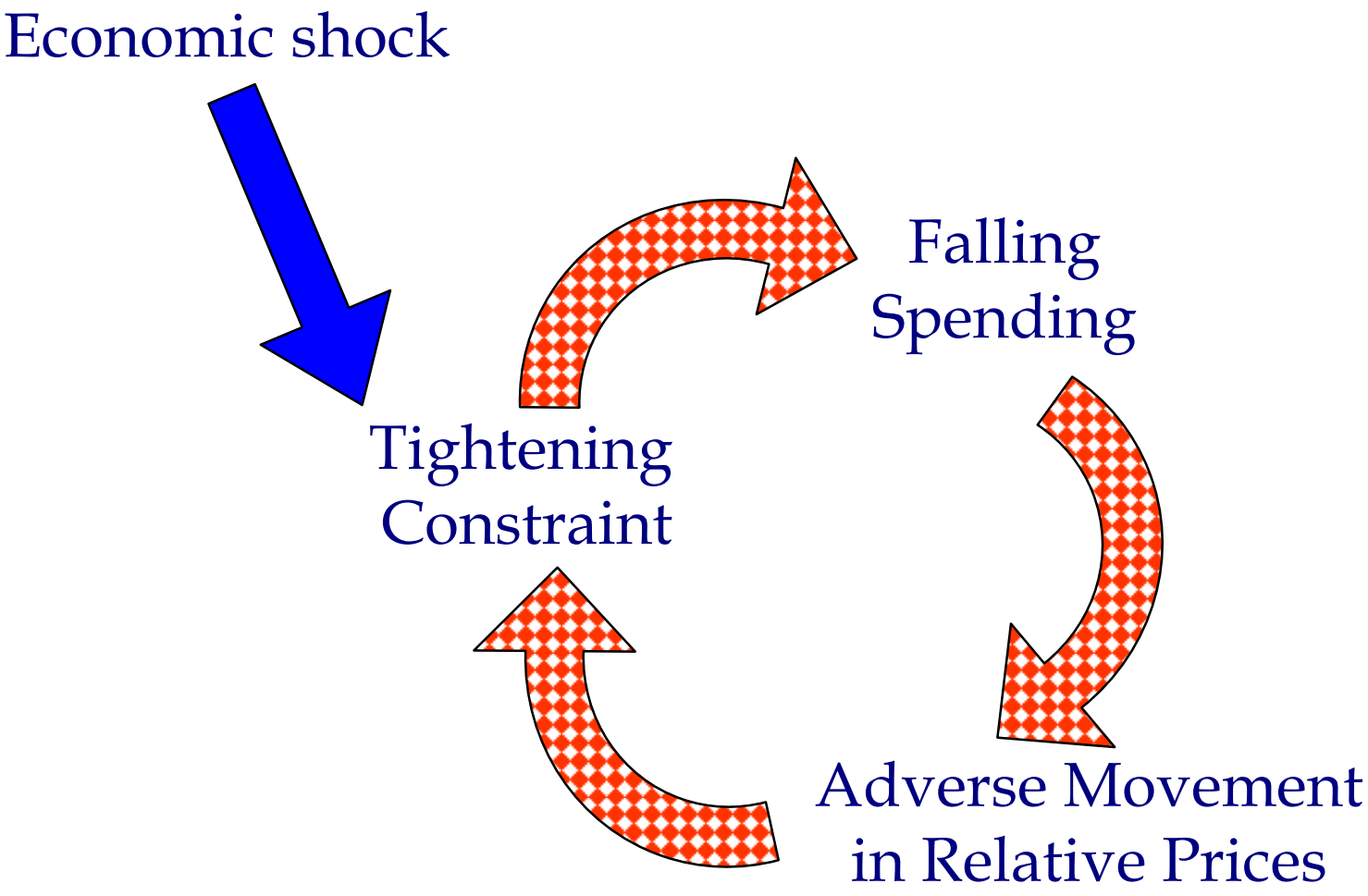
- *borrowing is subject to constraints*
- *constraints depend on asset prices*
- *potential for feedback spirals between*
  - *collapsing asset prices*
  - *tightening borrowing constraints*
  - *declining spending*

$\rightarrow$ *financial accelerator, debt deflation, ...*

Feedback Spirals



Feedback Spirals



Key Findings

Key Results

1. *endogenous borrowing constraints amplify volatility*
2. *decentralized equilibrium is socially suboptimal:*
   - *excessive debt*
   - *excessive exposure to binding constraints*
   - *excessive volatility (systemic risk)*
3. *strong case for macroprudential regulation*

Relationship to Literature

- **Financial accelerator effects:** Fisher (1933), Kiyotaki-Moore (1997), Bernanke-Gertler-Gilchrist (1999), etc.
- **Deleveraging externalities:** Gromb and Vayanos (2002), Lorenzoni (2008), Korinek (2009)
- **Optimal policy in DSGE models with financial accelerator:** Bianchi (2010), Benigno et al. (2010), Bianchi-Mendoza (2010)
- **Empirical importance of amplification:** Adrian and Brunnermeier (2009), Adrian and Shin (2009ab), etc.

Model Structure

DSGE Setup in infinite discrete time

Two sets of agents:

1. Insiders who exclusively own an asset (tree), representing e.g.
   - entrepreneurs: more productive at operating an asset
   - households: put higher utility on owning their home
   - locals in small open economy: value local assets more
   - speculators: more risk-tolerant towards an asset
   - agents with informational advantage
2. Outsiders: large in comparison, provide credit at rate R

Debt is the only financial contract

Insiders

Optimization problem of representative insider:

- Hold $a_t = 1$ unit of tree
- Obtain endowment income $(1-\alpha)y_t$ and income from tree αy_t every period
- Trade trees, but solely among insiders
- Hold financial wealth w_t with outsiders
- Maximize utility

$$U_t = E_t\left(\sum_{s=t}^{\infty}\beta^{s-t}u(c_s)\right) \qquad \text{where } u(c_s) = \frac{c_s^{1-\gamma}}{1-\gamma}$$

$$\text{s.t.} \quad c_t + a_{t+1}p_t + \frac{w_{t+1}}{R} = (1-\alpha)y_t + a_t(p_t + \alpha y_t) + w_t$$

- and subject to a moral hazard problem that limits borrowing to

$$\frac{w_{t+1}}{R} \geq -\phi p_t - \psi$$

Equilibrium

- **State of economy:**
  summarized by (w, y)
- **Dynamics captured by 3 equilibrium functions:**
  $c(w, y)$, $p(w, y)$ and $\lambda(w, y)$
- **Equilibrium conditions:**

$$c(w,y) = \min\left\{w + e + y + \phi p(w,y), \left[\beta RE\left(c(w',y')^{-\gamma}\right)\right]^{-1/\gamma}\right\}$$

$$p(w,y) = \frac{\beta E\left[u'(c(w',y'))(y' + p(w',y')) + \phi\lambda(w',y')p(w',y')\right]}{u'(c(w,y))}$$

$$\lambda(w,y) = c(w,y)^{-\gamma} - \beta RE\left(c(w',y')^{-\gamma}\right)$$

- **Transition equation for wealth:**

$$w'/R = w + y - c(w,y)$$

Solution Method

- **Define grids $\mathbf{y}^g, \mathbf{d}^g$ for output shock and net worth**
- **Solution through reverse time iteration:**
  - in step k, start with functions $c_k(w, y)$, $p_k(w, y)$ and $\lambda_k(w, y)$
  - for any (w', y) derive unconstrained $t-1$ solution
  - for any $(w' > 0, y)$ derive constrained $t-1$ solution
  - for any y, determine threshold $\bar{w}(y)$ for binding constraints
  - concatenate constrained/unconstrained functions
  - interpolate $c_{k+1}(w, y)$, $p_{k+1}(w, y)$ and $\lambda_{k+1}(w, y)$

$\rightarrow$ endogenous gridpoints bifurcation method

Unconstrained Equilibrium

Unconstrained equilibrium (for sufficiently high net worth and output)
Given policy functions $c_k(w, y), p_k(w, y), \lambda_k(w, y)$ for next period,

- consumption $c^{unc}(w', y) = \left[\beta R E\left(c'^{-\gamma}\right)\right]^{-1/\gamma}$
- net worth $w^{unc}(w', y) = c^{unc} - y + \frac{w'}{R}$
- asset price $p^{unc}(w', y) = \beta E\left[\frac{u'(c')}{u'(c^{unc})} \cdot (\alpha y' + p')\right]$
- shadow price $\lambda^{unc} = 0$

- threshold level of net worth is $w \geq \bar{w} = -\phi p^{unc} - \psi$

Constrained Equilibrium

Constrained equilibrium (for low net worth, low output shock)
Given policy functions $c_k(w,y), p_k(w,y), \lambda_k(w,y)$ for next period,

- asset price $p^{con}(w',y) = -\frac{1}{\phi}\left[\frac{w'}{R} + \psi\right]$ from binding constraint
- consistent with a level of consumption of
  $c^{con}(w',y) = \left[\frac{\beta E\{u'(c')\cdot(\alpha y' + p^{con}) + \phi\lambda' p' | y\}}{p^{con}}\right]^{-\frac{1}{\gamma}}$
- net worth $w^{con}(w',y) = c^{con} - y - \phi p^{con} - \psi$
- shadow price $\lambda^{con}(w',y) = u'(c^{con}) - \beta R E\left[u'(c')\right]$

$\Rightarrow$ combine constrained/unconstrained policy functions
$\Rightarrow$ interpolate next iteration $c_{k+1}(w,y), p_{k+1}(w,y), \lambda_{k+1}(w,y)$

Amplification

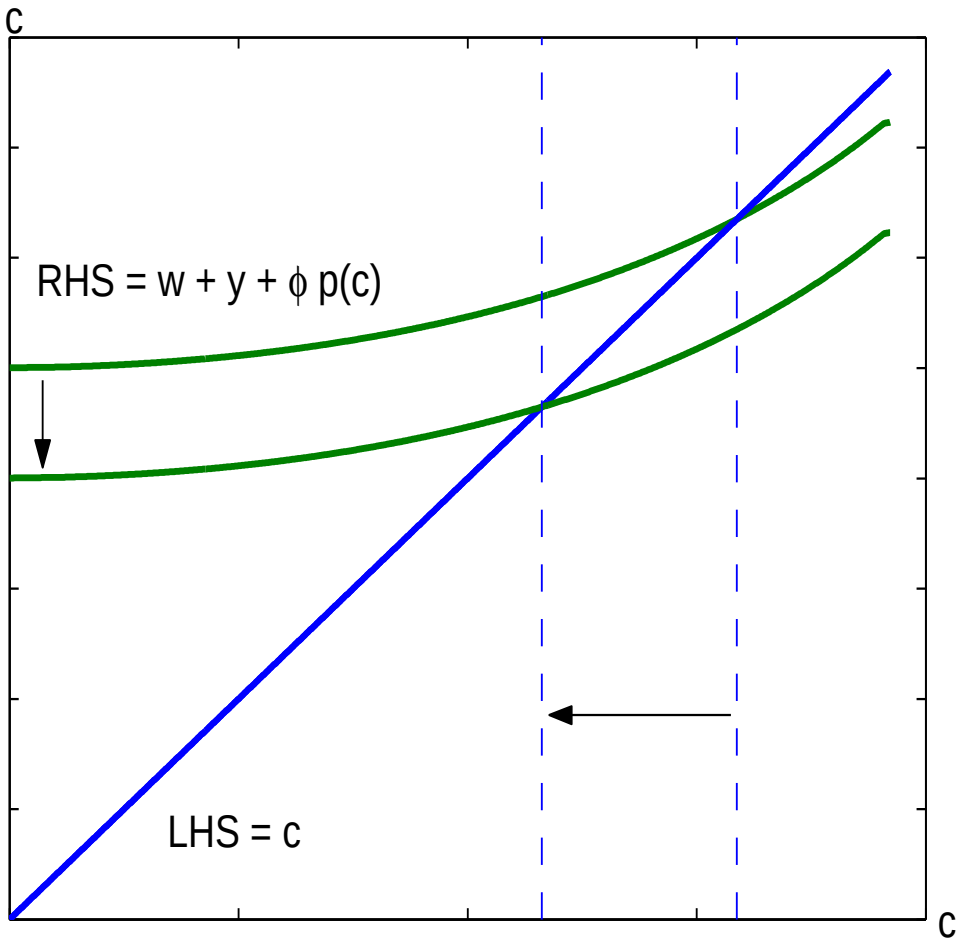


Figure: Equilibrium equation: $c \leq w + y + \phi p(c) + \psi$

Policy Functions

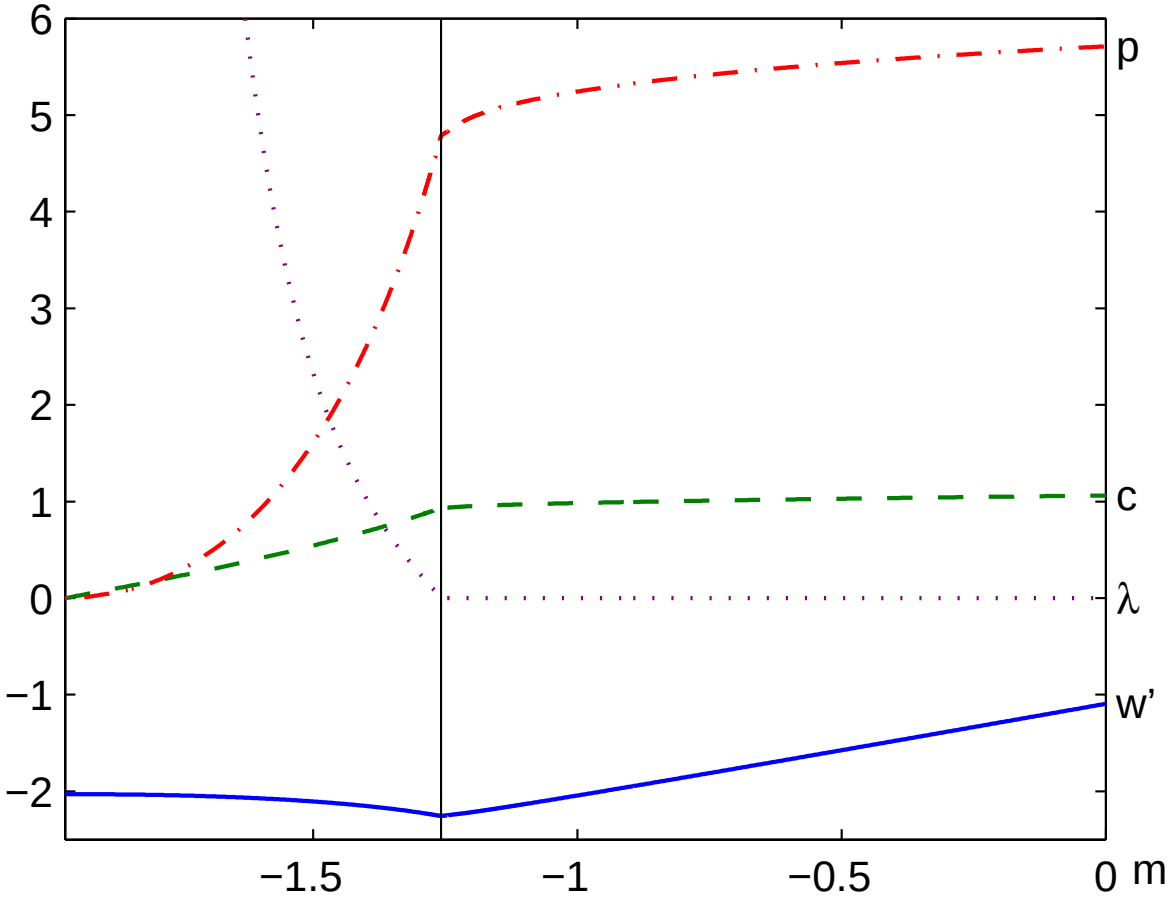


Figure: Equilibrium policy functions

Constrained Social Planner

Introduce a constrained social planner who

- is subject to the same borrowing limits as insiders
- coordinates (regulates) borrowing choices in the economy
- internalizes effect of choices on asset prices
- optimizes every period (no commitment)

Constrained Social Planner

Social planner's optimality condition:

$$u'(c_t) = \lambda_t + \beta R E_t \left[u'(c_{t+1}) + \phi \lambda_{t+1} \frac{\partial p_{t+1}}{\partial w_{t+1}} \right]$$

Interpretation of externality term $\phi \lambda_{t+1} \frac{\partial p_{t+1}}{\partial w_{t+1}}$:

- $\frac{\partial p_{t+1}}{\partial w_{t+1}}$ captures asset price increase resulting from higher wealth
- ϕ reflects resulting relaxation in borrowing constraint
- $\frac{\lambda_{t+1}}{E_t[u'(c_{t+1})]}$ represents utility cost of constraint

externality active if borrowing constraint is binding in the future

Equilibrium with Social Planner

Social planner solution:

- planner takes on less debt in periods before constraint is binding (systemic precautionary savings)
- less debt, less severe future constraints
- less volatility and financial fragility

$\rightarrow$ social planner reduces debt *and* uncertainty

Implementation of Constrained Social Optimum

Implementation through Pigouvian taxation:

- Introduce tax $\tau_t = \tau(w_t, y_t)$ on borrowing $-w_{t+1}/R$
- Rebate lump sum $T_t = -\tau_t \cdot w_{t+1}/R$

$$\max U_t = E_t \left(\sum_{s=t}^{\infty} \beta^{s-t} u(c_s) \right)$$

$$\text{s.t.} \quad c_t + (1-\tau_t)\frac{w_{t+1}}{R} = y_t + w_t + T_t$$

$$\frac{w_{t+1}}{R} \geq -\phi p_t - \psi$$

To implement constrained optimum, tax must satisfy

$$\tau(w_t, y_t) = \frac{\phi \beta R E_t \left[\lambda_{t+1} \frac{\partial p_{t+1}}{\partial w_{t+1}} \right]}{u'(c_t)}$$

Implementation of Constrained Social Optimum

Alternative mechanisms to implement Pigouvian tax:

- Direct taxation of debt
  (note: opposite of interest deductability on debt!)
- Prudential regulation: countercyclical capital requirements
  (benefit: uses existing frameworks)
- Limits on leverage / margin requirements
- Risk management systems

Calibration

Assumptions:

- capture booms and busts with binomial distribution for output $y_t \in \{y^L, y^H\}$ with probabilities π and $(1-\pi)$ (we set $\pi = 5\%$)
- calibrate parameters to match observed sectoral bust in 2008/09
- $\beta R < 1$ so insiders have a persistent motive for borrowing (we set $\beta = 0.96$, $R = 1.025$, $\gamma = 2$)

Table: Balance sheet data for US Households, SMEs and Corporations

	Assets			Debt		
	2008q2	2009q2	Chg.	2008q2	2009q2	Chg.
Households	74,273	64,425	-13.3%	14,418	14,116	-2.1%
SMEs	11,865	10,409	-12.3%	5,410	5,343	-1.2%
Corporations	28,579	26,521	-7.2%	13,039	13,597	+4.3%

Sectoral Calibration

Table: Sectoral Parameter Values

	α	ϕ	ψ	y_L
US Households	24.5%	3.1%	307%	0.963
US SMEs	20.0%	4.6%	197%	0.969

- Corporate sector: no credit crunch detected (corporate debt substituted for bank credit)
- Financial sector: parameter ϕ is in multiple equilibrium region $\rightarrow$ dynamics cannot be captured by our model

Model Dynamics

Model dynamics:

- Boom steady state w_H^{SS}: determined by trade-off of
  - impatience ($\beta R < 1$) versus
  - precautionary savings (smooth c in case of bust)
- During booms, insiders accumulate debt up to w_H^{SS}
  $\rightarrow$ create vulnerability to next bust
- During busts, binding constraints and debt deflation occurs

Wealth Dynamics

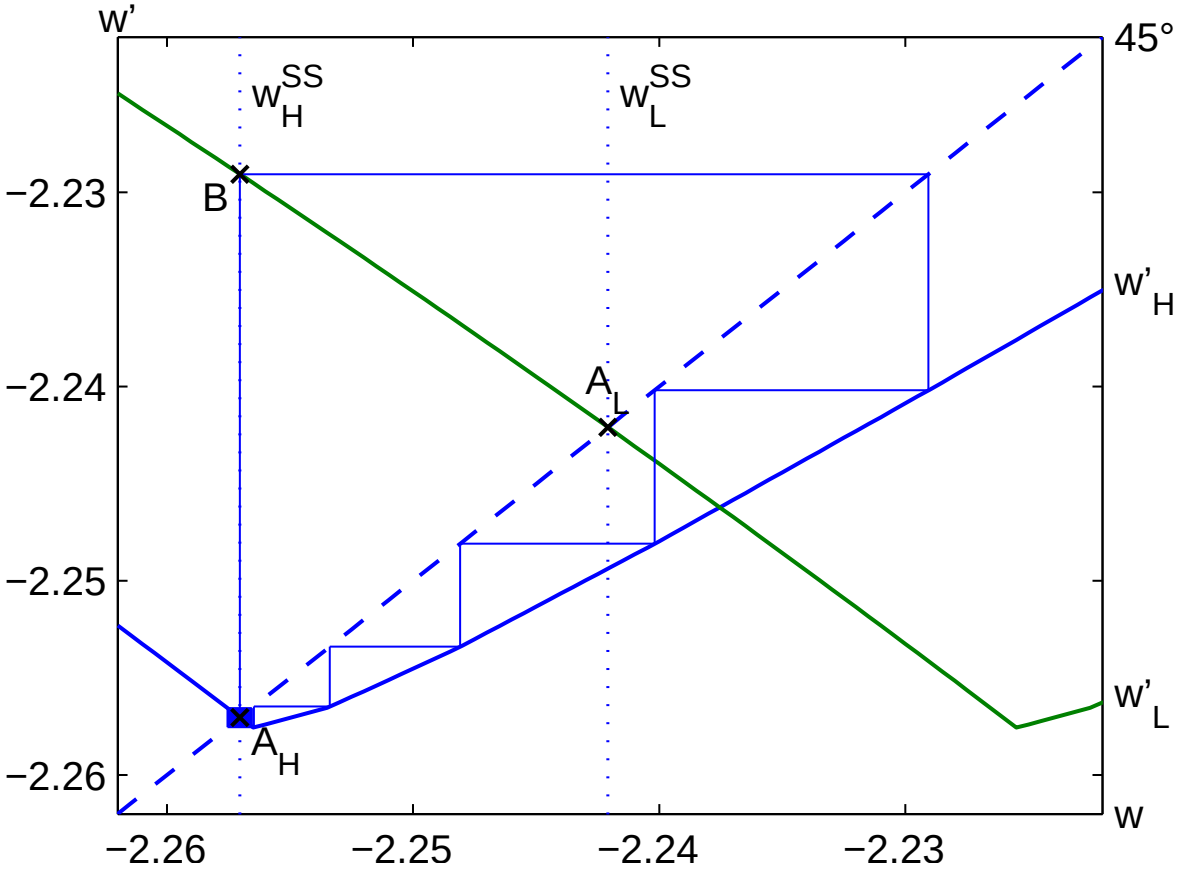


Figure: Next-period wealth function in states H and L

Decentralized Equilibrium Vs. Social Planner

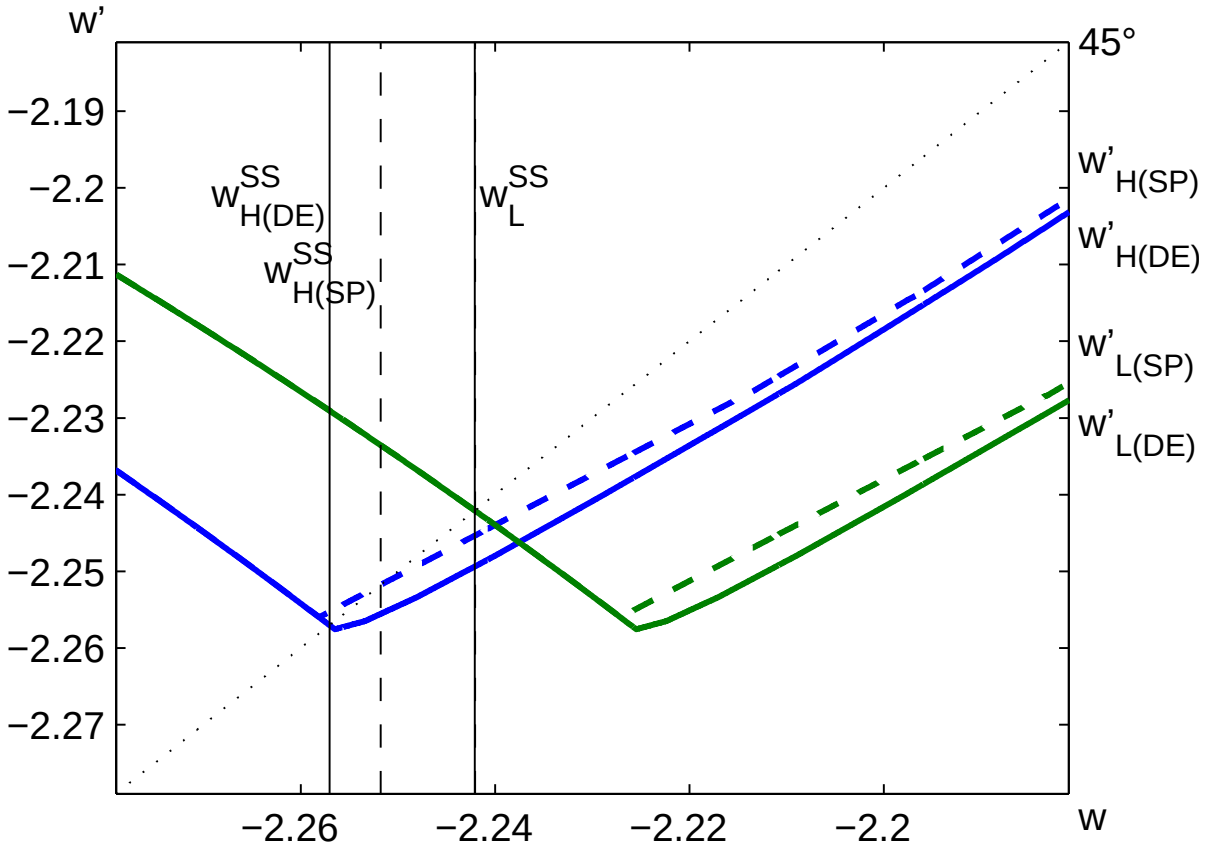


Figure: Decentralized equilibrium vs. planner's solution

Sample Paths of Macroeconomic Variables

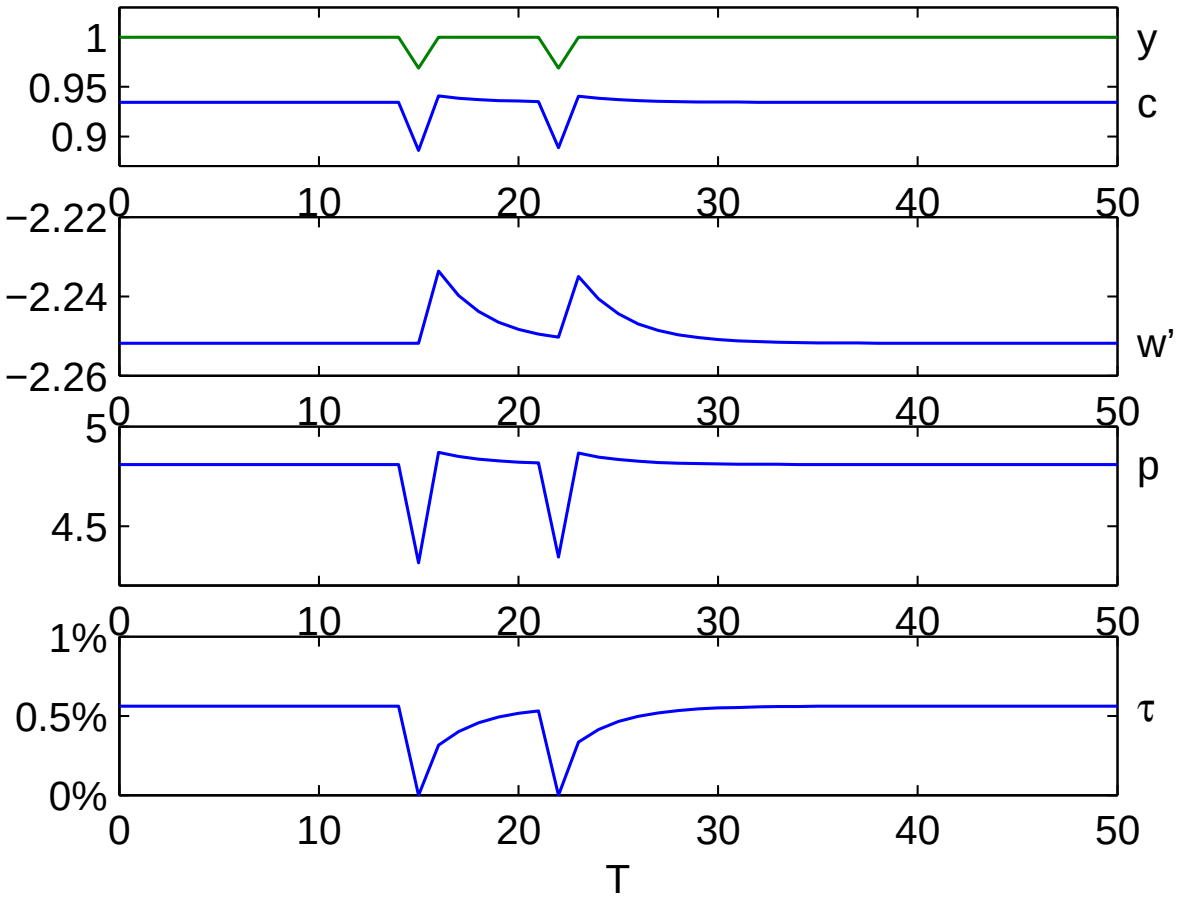


Figure: Sample path of planner's y, c, w', p and τ

Optial Sectoral Pigouvian Taxation

Table: Optimal magntiude of Pigouvian tax by sector

	τ_H^{SS}	Δc^{DE}	Δc^{SP}	Δp^{DE}	Δp^{SP}
US Households	0.48%	-6.80%	-5.99%	-13.33%	-11.75%
US SMEs	0.56%	-6.22%	-5.21%	-12.27%	-10.29%

Note: if impatience motive strong, planner chooses constrained w_H^{SS}
$\rightarrow$ debt levels determined by constraint, not τ_H^{SS}
(cp. Greenspan doctrine)

Financial Liberalization

Effects of liberalization that increases borrowing capacity:

After financial liberalization, insiders experience

- first a debt-financed consumption boom
  (honeymoon of liberalization)
- then lower and more volatile consumption
  (binding constraints amplify effects of output shocks)

Interest Rates and Financial Fragility

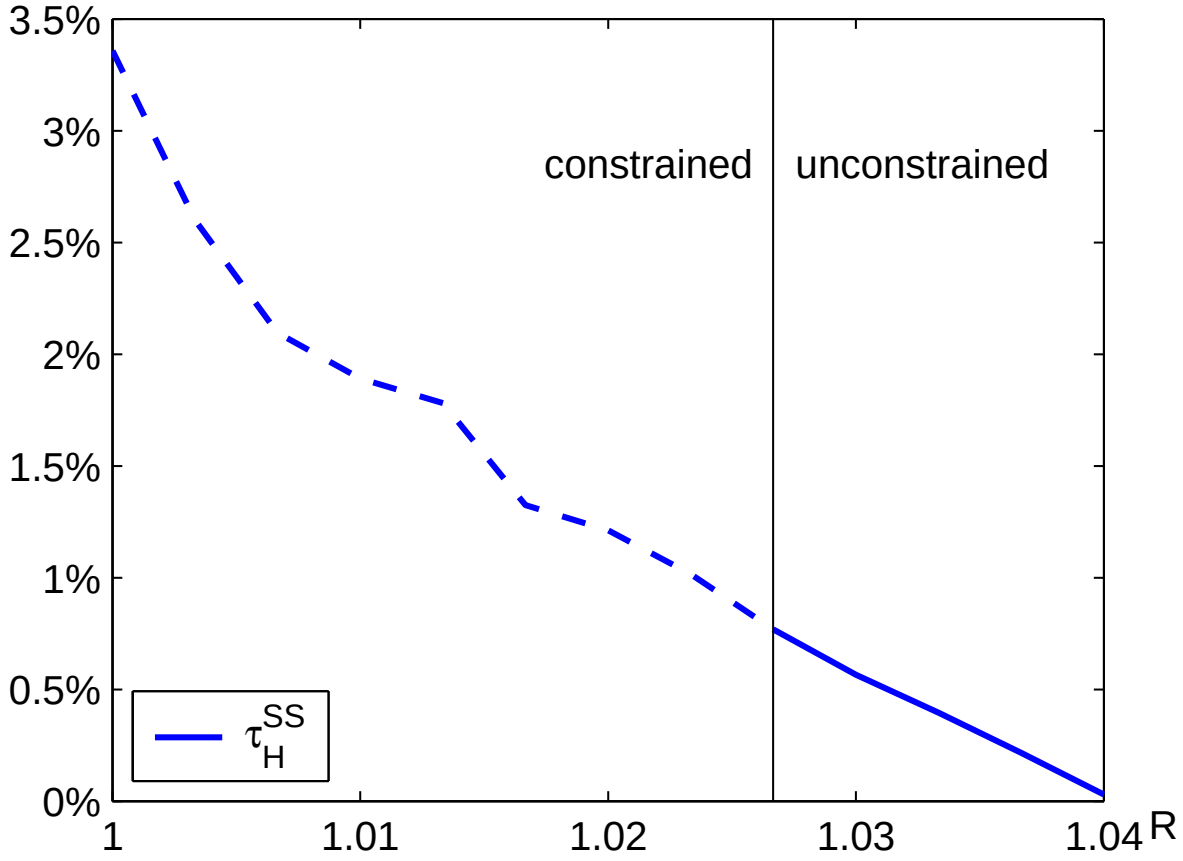


Figure: Dependence of externality τ_H^{SS} on interest rate

Financial Development and Fragility

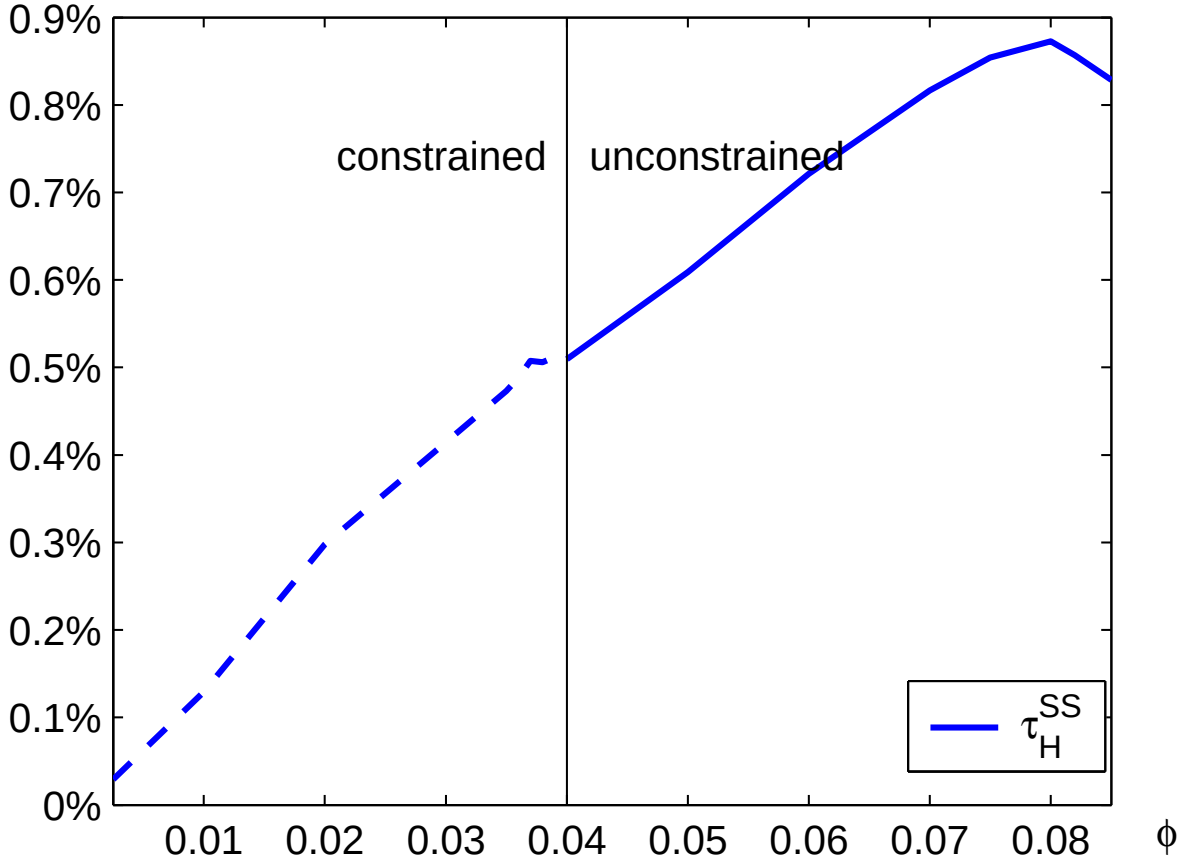


Figure: Dependence of externality τ_H^{SS} on pledgeability ϕ

Risk of Busts and Financial Fragility

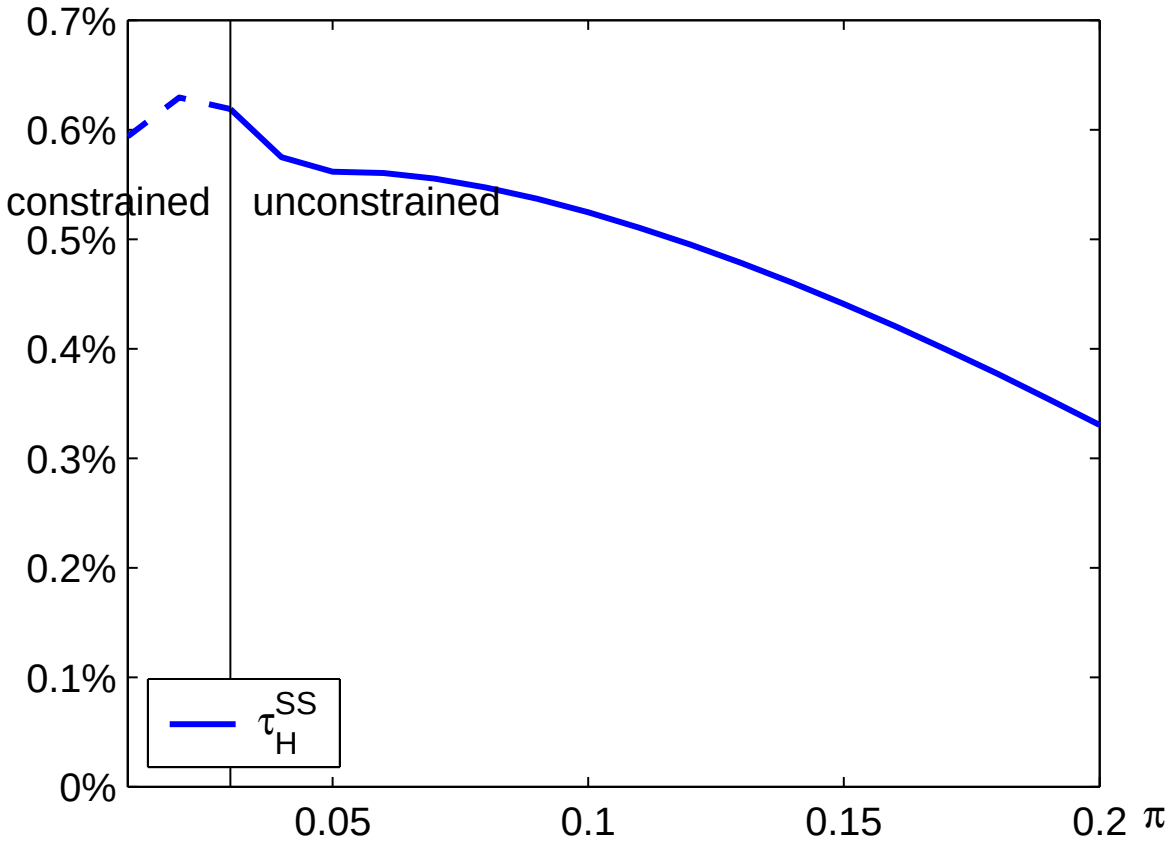


Figure: Dependence of externality τ_H^{SS} on crisis risk π

Financial Shocks

Adaption of Framework to Financial Shocks:

- we model busts as declines in ψ rather than y
- calibrating policy measure τ_H^{SS} yields almost identical results

Bailout Funds

Inclusion of Bailout Funds:

- assume policymakers tax insiders during booms and accumulate a bailout fund
- in bad times the fund is used to make a transfer to insiders

→ bailout will be precisely offset by increased risk-taking, unless tax in booms is large enough to make insiders constrained

Equity Investments

Assume insiders can sell an equity stake $s \leq \bar{s}$:

- outsiders immediately buy maximum possible $\bar{s}$ at price $\tilde{p} = \frac{E(y)}{R-1}$
- insiders experience a temporary consumption boom
- in the long run, equilibrium is almost unchanged
  (aside from parameter ψ, model is homogenous of degree 1)

$\rightarrow$ optimal macroprudential tax unaffected by equity investments

Financial Stability vs. Growth

Trade-off financial stability vs. growth:

- assume insiders need to invest x to obtain growth $g(x)$, where $g(\cdot)$ is concave
- binding constraints make investment more expensive
- in decentralized equilibrium, severe busts curtail growth

$\rightarrow$ optimal macro-prudential regulation increases stability and growth

Conclusions

- Endogenous financial constraints generate **financial amplification**
- In such an economy, decentralized agents **borrow excessively** $\rightarrow$ exacerbate boom-busts cycles in credit and asset prices
- Social planner can improve welfare by leaning against the wind through appropriate **macro-prudential regulation**